

The University of Chicago

GEOLOGY OF FORDSVILLE AND
CANNELTON QUADRANGLES

A DISSERTATION SUBMITTED TO THE FACULTY
OF THE DIVISION OF THE PHYSICAL SCIENCES
IN CANDIDACY FOR THE DEGREE OF DOCTOR
OF PHILOSOPHY

DEPARTMENT OF GEOLOGY AND
PALEONTOLOGY

1932

By

SAMUEL MARTIN MAYFIELD

Private Edition, Distributed by
THE UNIVERSITY OF CHICAGO LIBRARIES
CHICAGO, ILLINOIS

1934

The University of Chicago

GEOLOGY OF FORDSVILLE AND CANNELTON QUADRANGLES

A DISSERTATION SUBMITTED TO THE FACULTY
OF THE DIVISION OF THE PHYSICAL SCIENCES
IN CANDIDACY FOR THE DEGREE OF DOCTOR
OF PHILOSOPHY

DEPARTMENT OF GEOLOGY AND
PALEONTOLOGY

1932

By

SAMUEL MARTIN MAYFIELD

Private Edition, Distributed by
THE UNIVERSITY OF CHICAGO LIBRARIES
CHICAGO, ILLINOIS

1934



CHAPTER I

Introduction

Location and Extent

Fordsville and Cannelton Quadrangles of the Topographic Atlas of the United States Geological Survey lie along Ohio River in northwestern Kentucky and southern Indiana, about fifty-five miles southwest of Louisville and thirty miles east of Owensboro. They are bounded by north latitude $37^{\circ} 30'$ and 38° , and west longitude $86^{\circ} 30'$ and $86^{\circ} 45'$. The total area of the two quadrangles is approximately 475 square miles. However, about ninety-five square miles of Cannelton Quadrangle lie north of Ohio River in Indiana and are not included in this study, leaving approximately 380 square miles within the area covered by this project. This area includes the eastern one-half of Hancock County, the western one-fourth of Breckinridge County, the northeastern corner of Ohio County, and the northwestern corner of Grayson County. The eastern portion of the area is a part of the Kentucky "Pennyroyal", or Mississippian Plateau and the western part is embraced within the Western Kentucky Coal Field.

Importance

This is the first detailed study of this portion of the periphery of the Western Kentucky Coal Field, and there-

fore should constitute a distinct contribution to the knowledge of the terranes of this important geologic province. The structure of the area, especially the Rough River Uplift, is important from the standpoint of both scientific and economic interest. This work also adds a link to the chain of study which will finally reveal the physiographic history of the Ohio valley. The two quadrangles are supplied with natural resources above the average for Kentucky.

The areal and structural geologic maps of Fordsville Quadrangle have been published by The Kentucky Geological Survey. The Cannelton maps are still in manuscript form.

Field Work

The field work upon which this report and the accompanying geological maps are based was done during the months of June, July, and August, 1930 and June, 1931. Except for two days spent in the checking of stratigraphy and structure by Doctor A. H. Sutton, the field work was done entirely by the author.

Description of Locations

The Kentucky 15' Quadrangles are divided by the 5' lines of latitude and longitude into nine smaller sections, which may be designated as rectangles and for purposes of location, some nomenclature of these rectangles is convenient. In this report each rectangle has been named from its

position and from some notable place, named on the topographic map, within the rectangle. On this basis, the seven rectangles in Cannelton Quadrangle, which have all or portions of their areas in Kentucky, are:- Northeastern or Yellow Bank Creek, West Central or Skillman, Central or Cloverport, East Central or Stephensport, Southwestern or Patesville, South Central or Tar Springs, and Southeastern or Hites Run. The nine rectangles in Fordsville Quadrangle are: Northwestern or Easton, North Central or Tar Fork, Northeastern or McQuady, West Central or Fordsville, Central or Vanzant, East Central or Glen Dean, Southwestern or Olaton, South Central or Hites Falls, and Southeastern or Tousey. Many points have been located with reference to certain definite topographic and cultural features such as streams, hills, schools, churches, and towns.

Previous Geological Work

Several brief reports on special phases of the economic geology of the region have appeared at different times since the days of David Dale Owen, 1854, but the only important systematic geologic work done in the area was by P. N. Moore¹ in 1878 and 1884, and by Charles Butts² in 1917.

1. P. N. Moore. On the Geology of the Region Adjacent to the Western Coal Field, Kentucky Geological Survey, Report of Progress, Vol. 4, New Series, pp. 389-421, 1878.

2. Charles Butts. The Mississippian Series in Western Kentucky, Kentucky Geological Survey, 1917.

The former was reconnaissance work and the latter merely described a number of sections of the Chester Series within the two quadrangles.

Acknowledgments

The writer is chiefly indebted to Dr. W. R. Jillson, Director of the Kentucky Geological Survey, whose cooperation has made this work possible. A debt of gratitude is also due Dr. A. H. Sutton, of the Department of Geology of the University of Illinois and the Kentucky Geological Survey, who spent two days in the field with the author, checking the stratigraphy and structure, and who also aided in the identification of the fossils. The manuscript of the report was read and corrected by Dr. Carey Croneis and other members of the staff of the Department of Geology and Paleontology of the University of Chicago.

CHAPTER II

Topography

Introduction

The field work for topographic base maps of Fordsville and Cannelton Quadrangles was done by the United States Geological Survey in cooperation with the Kentucky Geological Survey during the field season of 1929. The advance sheets only of these maps are available at present. These are on a scale of $\frac{1}{48,000}$ with a twenty foot contour interval. This area is included in the physiographic province of the United States designated by Fennemann¹ as a "Possible Western section (not delimited)" of the "Interior Low Plateaus" and is characterized in general as a "Low maturely dissected plateau with silt filled valleys."

Topography and Relief

After the uplift following the Cretaceous peneplanation of this region, the surface of the Fordsville and Cannelton Quadrangles was a low plateau, essentially plane, with possibly a gentle slope to the southwest. The common occurrence and wide distribution of flats, terraces, and hill tops at or near the present 700 foot elevation and only 100

1. N. M. Fennemann. Physiographic Provinces of the United States, Annals, Association, American Geographers, Vol. XVIII, No. 4, 1928.

feet below the highest tops which are regarded as the last remnants of the Cretaceous peneplain, suggests that the initial uplift following peneplanation in the Cretaceous was about 100 feet. A deposit of Tertiary gravel at the 700 foot level one and one-half miles northeast of Stephensport is additional evidence in support of this conclusion. Likewise terraces, flats, and deposits at or near the present 600 foot level seem to suggest that a second uplift of about 100 feet occurred after an interval of erosion and terracing. The same features - flats, terraces, hanging valleys, and deposits - are even more evident at the 500 foot level, suggesting a third uplift of about 100 feet. The features at the 500 foot level now stand 90 feet above the level of the Ohio valley plain of Pleistocene and Recent origin, 150 feet above the surface of the Ohio River at low water and considerably more than that above the pre-pleistocene bottom of the river. This suggests a fourth uplift, an increase in volume of the river, or both. Thus there is considerable evidence, which cannot be easily ignored nor fully refuted, that the region has reached its present elevation through a series of four uplifts separated by intervals of stability and erosion. However, the evidence obtained from the study of a limited area is inconclusive and it will require detailed work covering a much larger portion of the Ohio valley to prove or disprove it.

On the other hand, there is much in the area to indicate that a too close adherence to the foregoing theory would be unwise at the present time. Terraces or berms, flats, and rolling uplands in this area nearly always have underlying resistant strata which could be regarded as responsible for their existence. Not only are most of the relatively level surfaces above the valley bottoms developed on resistant beds, but the surface commonly slopes with the dip of the beds. Moreover, flats, terraces, and tops occur at various elevations, intermediate between the assumed former base levels. Furthermore, it may be possible that the deposits of sand and gravel at different levels were left in abandoned meanders of streams as they cut downward toward a base level established by a single uplift at the close of Cretaceous time.

There is one more possible explanation of this condition. Base leveling and resistant strata may have combined in producing the terraces or berms, flats, and rolling uplands; these features being best developed and longest preserved where base level and resistant rock coincided in elevation or where the base level was slightly below the resistant rock.

In the course of its physiographic history, the region has become greatly dissected by stream erosion and now presents a mature development generally with narrow divides between narrow stream valleys, whose slopes of varying degrees of steepness comprise the greater portion of the sur-

face. However, in many localities, and especially in the eastern portion of the area, relatively broad, rolling uplands occur, upheld by resistant sandstone members of the Chester and Pottsville and most of the alluvium-filled valleys have nearly level floors except where affected by recent trenching. In a few localities along the folded and faulted zones, structure appears to have been an important factor in the development of the surface forms.

Regardless of what may have been the diastrophic history of the area, excellent examples of the effects of bedrock on topography occur in nearly all localities. With few exceptions the sandstone strata cap the uplands, underlie the broader terraces and flats, or occur in steep slopes and vertical cliffs. In places also, they form the beds of the small streams. Remarkable examples of sandstones capping uplands are found in the broad, nearly level areas along Highway 60 in the vicinity of the town of Hardinsburg. The limestone and shale formations, in general, underlie the relatively gentle slopes, and terraces on the slopes, with sandstones above and below or they are the surface formations in the wider valleys. However, there are exceptions to this, for in places the more massive limestone members crop out in bluffs along the streams or cap small hills, and elsewhere sandstones underlie more gentle slopes.

All the sand-bearing formations in both the Chester and Pottsville vary greatly and a massive, highly resistant

sandstone at one point may be represented, only a short distance away, by a weak shale or shaly sandstone. These changes in lithology are accompanied by striking changes in the topographic expressions of the formations from place to place. The localities underlain by massive sandstone can be recognized easily from the topographic map, by the bluffs and terraces it forms, especially if the sandstone is situated about midway in the relief.

This relationship of bed rock to surface form is characteristic of the Pennsylvanian strata as well as of the Chester series. In the Pennsylvanian, shale beds take the topographic role of the limestone-shale formations of the Chester and there is not much difference between the topography of the Chester and the Pottsville areas of outcrop.

The most resistant rock in the whole area is the basal Pottsville conglomerate and sandstone which occurs in Skillman Rectangle of Cannelton Quadrangle. Steep bluffs and vertical and overhanging cliffs characterize the outcrops of this formation. Southward, the conglomerate changes rapidly to less resistant sandstone and shale and its characteristic topographic expression disappears.

Splendid examples of the effects of structure on topography occur along the Rough River Uplift across the southern part of the Fordsville Quadrangle. The resistant sandstone beds in the steeply dipping strata frequently stand out as low linear ridges or hogbacks and commonly, especially

along the southern flank of the anticline, the land surface coincides with the surface of dipping resistant beds thereby producing long regular slopes. A remarkable example of this exists in the dome three quarters of a mile southeast of Yeaman where the thin Hardinsburg sandstone cloaks the top and sides of the dome which has a closure of 70 or 80 feet on the eastern side and a southwestern flank which dips downward with the slope 200 feet in three-fourths of a mile.

Structure and resistant strata have also cooperated in producing a conspicuous narrowing of Caney Creek where it crosses the crest of the Rough River Uplift in Olaton rectangle. At the southern margin of the quadrangle where the valley is developed mainly in Pottsville shales and shaly sandstone, the valley bottom is about one and one-half miles wide, but where the stream cuts through the Chester beds at the crest of the anticline three quarters of a mile north of Olaton, the valley bottom is reduced almost to the width of the stream. Indian Creek valley in Skillman Rectangle is narrowed in its lower part by the dropping of the resistant Pottsville conglomerate to stream level by the Indian Creek Fault.

Structure is probably partly responsible for some of the sinkholes of the folded area. Large sinkholes have been produced in some relatively thin and steeply dipping beds of limestone where such features probably would not have developed had the beds been horizontal. The narrowing of the

valley of Rough River above Falls of Rough may be attributed partly to the steep down-stream dip which brings different resistant Chester beds successively down to water level. Rock Lick Creek, west of Glen Dean, is an example of a stream valley developed parallel to the strike in a resistant ledge. For several miles, this stream valley is in the Tar Springs Sandstone, very narrow, with a flat bottom and precipitous sides.

The rugged topography of relatively great relief midway between Cloverport and Stephensport is due partly to structure. Here a low westward plunging syncline has brought the resistant basal Pottsville sandstones so low that their removal by erosion has been delayed. The most rugged topography of the area is in the region of the southeastern corner of Hancock County, where many streams head. The slopes of this headwaters district are steep and the valleys quite narrow. The topography here is developed on frequently alternating shales and sandstones, no one bed of which is of any great thickness or prominence. The ruggedness is also partly due to the location near the heads of the streams where erosion has not been so great. Hilltops at the maximum elevation for the region, 800 feet, occur more frequently here than elsewhere in the two quadrangles.

The remarkable flatness of the surface of the alluvial filling of the valleys deserves special and perhaps

repeated mention. Along Rough River and all other streams the flats are almost level for miles except where affected by recent trenching. For example, on Adams Creek, which is a relatively small stream, the filling is half a mile wide and so level that it would not drain until ditched. This condition implies deposition in quiet, ponded water.

On the other hand, the surface of the alluvial deposits along Ohio River possesses considerable relief and may be best described by the term gently rolling. Broad, low swales and swells roughly parallel the stream as if deposition were affected by varying degrees of velocity of currents in different parts of the flood. On some of the larger alluvial plains along the Ohio, the natural levees of the Pleistocene river are present.

Cliffs have been mentioned before. The cliff-making formations are the Bethel, Cypress, Hardinsburg and Tar Springs sandstones and the Pottsville conglomerate and sandstones. Occasionally low cliffs are formed by the more massive limestone beds and by the sandstones of the Buffalo Wallow formation. The highest cliffs of the area are those produced by the Pottsville conglomerate in Skillman Rectangle, especially in Jeffry Cliff and Shafer Hill where rock houses 140 feet high occur. Tar Springs sandstone cliffs are best developed in the vicinity of Tar Springs and on Rock Lick Creek, where many are 70 feet high. Cypress Sandstone produces cliffs and rockhouses on upper Glover Creek and else-

where, while the Bethel is responsible for the same features on Caney Fork Creek in Stephensonport Rectangle.

These natural shelters were early discovered and appropriated by the aborigines, whose extensive occupancy of these homes, provided by nature, is attested by the presence of "hominy holes", chips from the manufacture of flint implements, pot sherds, stone and bone implements, huge piles of ashes, the bones of animals used for food, and even human bones. The tops of some of the cliff-rimmed areas also provided excellent natural fortifications for the prehistoric peoples. Jeffery Cliff in Skillman Rectangle was one of the largest and probably the most nearly impregnable prehistoric forts in Kentucky. It is a mile long, averages about one-fifth of a mile wide, and in prehistoric times the top could be reached only by difficult scaling at one or two points. Sand Knob, just north of Rough River on the eastern margin of Fordsville Quadrangle, was a prehistoric fort. The tops, rock houses, and the ground beneath these cliffs show evidence of long and extensive occupation by prehistoric peoples.

Waterfalls produced by the sandstone beds at the heads of small streams are of common occurrence and falls or rapids are developed at Falls of Rough by the lower Glen Dean limestone and at Hites Falls by the Tar Springs sandstone.

Scattered sinkholes have been developed at various places in all the limestone horizons from the Kinkaïd down,

but they are most common along the Rough River Uplift and especially on the eastern end of this structure where the development of sinkhole topography is almost as pronounced as that of the typical Kentucky karst regions. Sinkhole ponds are very rare. One occurs at the top of the hill one-half mile south of Cane Ford in Hites Falls Rectangle.

Landslides have modified the topography of the steep slopes of all the valleys to a greater or lesser degree, but landslide topography is best developed along Ohio River, at the points where the river is undercutting its valley sides as it is both northeast and northwest of Cloverport and northeast of Stephensport. Just north of Little Tar Springs landslide topography is especially well developed.

The type of topography described above is not unique for Fordsville and Cannelton Quadrangles. It is in agreement with the topography of all of the periphery of the Western Kentucky Coal Field.

The maximum relief in the two quadrangles is about 470 feet. The highest point, the hilltop near the Persimmon Flat School, three and one-half miles northeast of Cloverport, and the lowest point, Ohio River, are within one and one-half miles of each other. Ohio River at low water is about 360 feet and the highest point on Persimmon Flat is 832 feet. Knob Lick Hill in the northern part of McQuady Rectangle and Powel Hill in the eastern part of Glen Dean Rectangle are respectively 830 feet and 824 feet. The

highest points in the generally elevated region in southeastern Hancock county are a little more than 800 feet. The highest and the lowest points are so near together that the maximum relief for the area might also be called the maximum local relief, but a local relief of from 100 to 300 feet is usual.

Drainage

All except the northern one-sixth of Fordsville Quadrangle lies within the drainage basin of Rough River, which is a tributary of Green River. Rough River enters Fordsville Quadrangle near the middle of the eastern margin and meanders excessively in an extremely irregular course generally southwestward through a usually broad alluvial plain, leaving the western margin of the quadrangle several miles north of the southwestern corner. Its course may be controlled to some extent by the Rough River Uplift, but this is doubtful. It is more probably the result of entrenchment of meanders, which existed on the Cretaceous peneplain, and recent modification by Pleistocene valley filling. Three southern tributaries of the Rough, Caney, Mistaken, and Short Creeks cross the Rough River Uplift before joining the main stream. These also have held their courses since the Cretaceous and there is little evidence of structural adjustment in their courses except a narrowing of the valleys where they cross the crest of the anticline. Some smaller southern

tributaries are Cane Run, Brown's Creek, Little Short Creek, Diamond Branch, and Pleasant Run. The larger northern tributaries of Rough River are Adams Creek, Pond Run, Pipe Run, and Rock Lick Creek, all of which have alluvium filled valleys and many branches which, together with the smaller tributaries of the Rough, drain a wide territory.

The northwestern corner of Fordsville Quadrangle and a small portion of the southwestern corner of Cannelton Quadrangle are drained by the headwaters of Panther Creek, which also flows west into Green River. The alluvial valley filling in the Panther Creek drainage extends far up toward the valley heads.

The remainder of Fordsville Quadrangle and all of Cannelton Quadrangle are drained by streams which flow directly into Ohio River. The stream which enters the Ohio farthest from the area is Blackford Creek, whose headwaters drain a considerable portion of the southwestern part of Cannelton Quadrangle.

The Clover Creek drainage basin covers the major portion of the Kentucky part of Cannelton Quadrangle and the northeastern part of Fordsville Quadrangle. It is not a long creek, but its numerous large tributaries enable it to drain a large area which is roughly circular in outline. It is in the valleys of this drainage basin that most of the ice-raftered erratics were observed.

Most of Skillman Rectangle drains northwestward to

the Ohio through Lead and Indian Creeks. Between Cloverport and Stephensport drainage is to the Ohio through several small streams including Slick Creek, Goshagen Creek, Bull Creek, and Town Creek.

Sinking Creek, which enters the Ohio at Stephensport, receives most of the drainage along the eastern margin of Cannelton Quadrangle. Yellow Bank Creek crosses the narrow northeastern corner of Cannelton Quadrangle. An interesting and important feature of the drainage is the great southern meander of the Ohio in the middle of Cannelton Quadrangle on the southern tip of which the town of Cloverport is located.

The karst type of drainage is well developed only in a small area within the fault zone in the extreme southeastern part of the Fordsville quadrangle where the uplift brings the Ste. Genevieve and the Lower Chester to the surface.

Several abandoned meanders occur along Rough River, the most conspicuous one being at Falls of Rough. Clover Creek, having a steeper grade to the Ohio than its neighboring streams, is probably enlarging its drainage basin, the divides migrating at the expense of Rough River, Panther Creek, and Blackford Creek drainage areas. As stated earlier, many of the alluvial plains in the valley bottoms require artificial drainage. This is especially true along Adams Fork Creek, Panther Creek, and Blackford Creek, where the government has excavated large ditches.

Culture

There are four incorporated towns wholly or partly within the two quadrangles, Cloverport, with a population of 1324; Hawesville, which is only partly within Cannelton Quadrangle, with 790 inhabitants, and Stephensport, with a population of 151, are on the Ohio River and the Louisville and Nashville Railroad in Cannelton Quadrangle. The fourth incorporated place is Fordsville, on the Illinois Central Railroad and the Louisville and Nashville Railroad, with a population of 573. The population of all of these towns and also of the region as a whole has been decreasing since 1910. Cloverport has an important tile factory, produces macadam, mills flour, and is a railroad and river shipping point for an extensive area. Stephensport is a gathering and distributing center for the surrounding rural population. Only a small part of Hawesville is within the area now being considered. Fordsville is a railroad and trading center for farmers and oil prospectors and operators. Skillman and Addison are small towns on the Louisville and Nashville Railroad and the Ohio river. Government lock and dam No.45 is located at Addison. Elmitch, Askin, Vanzant, Rockvale, Glen Dean, and McQuady are railroad stations or villages and small towns on the Louisville and Nashville Railroad which crosses the middle of Fordsville Quadrangle. Most of these places have facilities for pickling cucumbers, which are grown extensively in this region as a special crop.

Falls of Rough, on a spur line from the Louisville and Nashville Railroad, is a unique little town with a flour mill and a saw mill run by power generated by Rough River. Narrows, Davidson, and Olaton are railroad stations and villages on the Illinois Central Railroad in the southwestern part of Fordsville Quadrangle. Yeaman and Balltown are little cross-roads trading and social centers for the farmer folk. There are also several other small country stores and postoffices scattered through the area.

Country schools are generally of the one-room type usually found in Kentucky and are distributed from three to four miles apart. Consolidation of the rural schools will be impossible until the roads are improved. Country churches, generally of the framed variety built many years ago, appear neglected here as they do commonly throughout the State.

Farm homes and buildings are generally good in the eastern or dominantly Chester portion of the area, where the soil is best. Farther west in the more hilly and sandy country they are not so good and not so numerous. Nearly all of the farm houses are of the frame type, but occasionally a boxed house is seen and even a few old log houses are still in existence.

The Louisville and Nashville Railroad has a line paralleling Ohio River from Hawesville to Stephensport and another crossing the middle of Fordsville Quadrangle from east to west with a branch line to Falls of Rough. The

Illinois Central Railroad has a line running northwest-southeast through the southwestern part of Fordsville Quadrangle.

United States Highway 60, with an asphalt surface, crosses Cannelton Quadrangle in a northwest-southeast direction. This, with about two miles of state highway, west from Fordsville, is the only improved road in the area. The dirt roads of the area are rough, narrow, steep and dusty part of the year and muddy most of the remainder. The rather extensive use of tractor-drawn graders on the dirt roads is doing much good, especially in dry weather.

Over most of the area, automobiles are practically useless during wet weather and that is a considerable portion of the year. In general, the roads follow either the valley bottoms or the ridge tops.

CHAPTER III

Stratigraphic Geology

Introduction

General Remarks

The Ste. Genevieve limestone is the oldest formation exposed within the Fordsville and Cannelton quadrangles. Still older beds belonging to the middle and lower Mississippian groups and to the Devonian, Silurian, and Ordovician systems crop out in succession toward the crest of the Lexington Dome on the Cincinnati Arch which lies about one hundred miles due east. These older formations have also been penetrated during drilling operations at a few places within the area under consideration.

Above the Ste. Genevieve limestone, the whole of the Chester Series of the Mississippian System and the Pottsville of the Pennsylvanian system constitute the hard rock formations which are exposed at the surface. Upon these lie small, scattered patches of unconsolidated Tertiary sands and gravels and valley bottom fillings of Pleistocene and Recent alluvium. Locally, near the Ohio river, a thin mantle of loess is also exhibited. The relatively steep regional dip toward the west and the Rough River uplift cause the exposure of about 1,000 feet of strata.

Unexposed Strata

Knowledge of the thickness and character of the unexposed rocks of the area is based upon a few well logs poorly kept and difficult of interpretation. The two which follow are the best deep well logs obtainable.

Log of well at Stephensport, drilled about 1880. Modified from Butts¹, Section No. 27. Casing head elevation 405 feet. Casing head strata lower Paint Creek limestone.

Mississippian System	Thickness	Depth
<u>Chester Group</u>		
Shale (Paint Creek	3	3
Limestone (Paint Creek)	10	13
Light Brown Sandstone (Bethel ("Barlow" oil sand))	35	48
Gray and white limestone, some crinoidal (Renault)	63	111
Black shale (Renault)	5	116
<u>Meramec Group</u>		
White, light gray and dove colored limestone (Ste. Genevieve)	105	221
Gray, oolitic limestone (Ste. Genevieve)	36	257
Dove colored lithographic limestone (Ste. Genevieve)	24	281
Light gray oolitic limestone (Ste. Genevieve - possible oil sand)	17	298
White and gray limestone (St. Louis)	103	401
Black shale, limestone and sandstone mixed (St. Louis)	10	411
Light and dark gray limestone (St. Louis)	40	451

1. Charles Butts. Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917. Chart of Sections.

Brown limestone, black shale and crinoidal limestone (St. Louis)	28	479
White sandstone (St. Louis)	5	484
Dove colored, black, dark gray limestone (St. Louis)	123	607
White sandstone (St. Louis)	6	613
White, light gray, dark gray, brown, and dark limestone (St. Louis)	90	703
Dark gray, crystalline limestone (St. Louis)	20	723
Light and dark gray limestone (St. Louis)	61	784
Black shaly limestone, Warsaw (Cloverport gas sand (?))	19	803
White limestone, fossils, black limestone (Warsaw)	30	833
White, fossiliferous limestone (Warsaw)	25	858

Osage Group

White, light gray and gray limestone, some sandy and some crystalline (Osage)	340	1198
Impure, black limestone (New Providence)	100	1298
Fine grained, black, limey sandstone (New Providence)	23	1321

Devonian System

Black shale (Chattanooga) (Brandenburg gas horizon "corniferous" oil and just below)	62	1383
--	----	------

Log of deep well near Victoria postoffice, just east of the Hancock-Breckinridge county line and near the southern margin of Cannelton Quadrangle, on property now owned by the Hancock Land and Improvement Company. Casing head elevation 542 feet A.T. Casing head strata, Buffalo Wallow 68 feet below the Kinkaïd limestone and 128 feet above the base of the Menard limestone, drilled in 1921. Total depth 3,145 feet.

Mississippian System

Strata	Thickness	Depth
Surface materials	14	14
Shale, light colored (Buffalo Wallow)	5	19
Limestone, white (Buffalo Wallow)	6	25
Shale, gray (Buffalo Wallow)	8	33
Limestone, gray (Buffalo Wallow)	4	37
Shale, gray (Buffalo Wallow)	13	50
Limestone, white to gray (Buffalo Wallow)	32	82
Shale, mainly, light to dark (Buffalo Wallow)	38	120
Sandstone and dark shale (Tar Springs) "Jett Oil Sand"	23	143
Limestone, dark (Glen Dean)	1	144
Shale, Calcareous (Glen Dean)	14	158
Limestone, dark (Glen Dean)	4	162
Shale, dark gray (Glen Dean)	1	163
Limestone, dark gray (Glen Dean)	5	168
Shale, dark gray (Glen Dean)	29	197
Limestone, dark crystalline (Glen Dean)	3	200
Shale, dark (Glen Dean)	2	202
Limestone, dark crystalline (Glen Dean)	15	217
Sandstone and shale (Hardinsburg "Jones Oil Sand")	11	228
Limestone, dark to light (Hardinsburg and Golconda)	37	265
Shale (Golconda)	19	284
Limestone, white to gray (Golconda)	52	336
Shale, dark to light (Golconda)	22	358
Limestone, slaty (Golconda)	12	370
Sandstone, with shale Cypress ("Jackson" Oil Sand)	62	432
Limestone, (Paint Creek)	24	456
Sandstone, white (Bethel) ("Barlow" oil Sand)	13	469
Limestone, white to dark (Renault and Ste. Genevieve)	231	700
Limestone, oolitic, white (Show of oil) Ste. Genevieve - possible oil sand)	170	870
Limestone, carrying in color and of varying degrees of purity (St. Louis, Warsaw, and Upper Osage)	820	1690
Shale, Greenish (New Providence)	30	1720

Devonian System

Shale, black (Chattanooga) (Brandenburg gas horizon)	198	1918
Limestone, white ("Corniferous" oil sand)	52	1970

<u>Silurian System</u>	Thickness	Depth
Limestone, yellow to white	170	2140
<u>Ordovician System</u>		
Limestone of varying colors and textures, at bottom compact like High-bridge limestone, Sunny Brook oil horizon about the middle of this interval	1005	3145

In the C. T. Whittinghill well one-quarter of a mile south of Tristler School in Vanzant Rectangle of Fordsville Quadrangle, the casing head elevation is 678 feet A.T. beginning in the Pottsville at about one hundred feet above the Kinkaid limestone. In this well the Chattanooga shale is 105 feet thick and lies between 1971 and 2076 feet beneath the surface. This black shale, so conspicuous throughout much of the Ohio Valley, is a good horizon marker in deep drill holes of this area.

The above sections indicate a thickness of the Iowa Series of approximately 1200 feet, which is 500 feet thinner than in the Princeton Quadrangle², 175 feet thinner than in the Cave in Rock and Galconda Quadrangle², but thicker than in Edmonson County³.

The Chester Series averages about 570 feet thick and is all exposed within the region. About 300 feet of

2. Stuart Weller, Kentucky Geological Survey, Ser. 6, Vols. 4, 10, 26.

3. J. Marvin Weller, Kentucky Geological Survey, Ser. 6, Vol. 28, p. 89, 1927.

Pottsville strata are represented in the area. The several stratigraphic units in the geological column as exposed in this part of Kentucky, will be described in order, beginning with the oldest.

Descriptions of Exposed Formations

Mississippian System

Iowa Series

Ste. Genevieve Limestone

Name. The Ste. Genevieve limestone was named by Shumard⁴ in 1859 from exposures which occur along the Mississippi river bluffs near Ste. Genevieve, Missouri.

Distribution. In the Cannelton and Fordsville quadrangles, this formation crops out in only three small areas in three adjoining fault blocks in the southeastern corner of Fordsville Quadrangle. Less than one-half of the total thickness of the formation is exposed.

The beds are all dipping steeply and were more or less fractured and folded in the Rough River disturbance. A few miles to the east of this area in Breckinridge and Grayson counties, the Ste. Genevieve crops out extensively.

Thickness. The thickness of the Ste. Genevieve can be determined only approximately. The deep well log at Stephensport shows about 180 feet of limestone referable to

4. B. R. Shumard. Observations on the County of Ste. Genevieve, St. Louis Academy of Science. Trans., Vol. I, 1859, p. 406.

the Ste. Genevieve while the Victoria well seems to have considerably more of the Ste. Genevieve type of limestone. Farther east in Breckinridge County it is about 180 feet thick and probably 180 to 200 is about the normal thickness of the Ste. Genevieve in Fordsville and Cannelton Quadrangles.

Topography. In the small fault block just east of Tousey, the Ste. Genevieve forms the lower half of the steep west face of a hill and crops out in the bed of a stream. Here the beds are dipping steeply into the hill. In the long sub-oval fault block east of Tousey, a small outcrop of almost vertical beds of Ste. Genevieve also underlies a hillside and a small stream flat. The remaining outcrop, in the fault block in the southeastern corner of Fordsville Quadrangle, dips to the north and is pitted by many sink-holes and roughened by solution along bedding and joint planes. One large sink receives all the overflow drainage from an extensive territory to the east and leads it underground to emerge in the big spring at Tousey.

Lithologic Character. The Ste. Genevieve is composed of limestone, except for occasional thin shale partings and a moderate proportion of chert. The color of the limestone varies from nearly white or light gray to bluish, and there are a few thin, buff-colored beds of lithographic texture. Much of the Ste. Genevieve is finely crystalline to dense limestone containing oolites which vary in number

from a few scattered grains to the almost exclusive constituent of the rock. Cross bedding in the oolitic beds is a common feature. The Ste. Genevieve is not a highly fossiliferous formation and most of the beds are essentially barren of recognizable forms. Some of the beds of the formation, however, carry plates of Platycrinus penicillus, and splendid specimens of Lithostrotian harmodites were observed in two of the three areas of outcrop.

The Ste. Genevieve chert develops as irregular tabular masses up to two inches in thickness. It is of a dark blue or black color, breaks into angular fragments and weathers white. The chert is well exhibited in the outcrop at Tousey, where the Ste. Genevieve is weathered into characteristic rounded surfaces. The residual material from the Ste. Genevieve consists of red clay with included chert.

Stratigraphic Relations. The St. Louis-Ste. Genevieve contact is not exposed in this area, but the Ste. Genevieve probably overlies the St. Louis conformably, because this is the relation which the two formations uniformly bear to each other throughout the lower portion of the Ohio Valley. East of the Cincinnati Arch, there is a marked disconformity at this horizon.

The exact contact between the Ste. Genevieve and the overlying Renault has not been observed in this area because of the covering of residuum, talus, and forest debris,

but doubtless a disconformity separates them here as elsewhere in the Mississippi valley.

Correlation. The occurrence of Lithostrotion Harmodites and Platycrinus penicillus leaves little doubt that this is the Ste. Genevieve limestone which is widely distributed throughout the Mississippi and Ohio valleys from Iowa across Illinois, Indiana, and Kentucky, and as far south as Alabama. Furthermore, the Ste. Genevieve, wherever known is similar in lithology to that of this area.

Paleontology. The most important index fossil of the formation is the crinoid Platycrinus penicillus, whose characteristic stem plates, elliptical in outline with a row of marginal spikes, were observed on the weathered surfaces of the limestone in several places. This species does not occur above the Ste. Genevieve. Lithostrotion harmodites, a species of coral, which is limited to the Ste. Genevieve limestone, was observed in two localities, in one of which it covers an area of several square feet.

CHESTER SERIES

Renault Limestone

Name. The basal formation of the Chester Series in the Ohio Valley is the Renault Limestone, named by Weller⁵ from Renault Township, Monroe County, Illinois.

Distribution. The exposures of the Renault in the two quadrangles are few and limited in area, being confined to two small localities, one of which is in the southeastern corner of Fordsville Quadrangle in the vicinity of Tousey where it crops out within four different adjoining fault blocks. The other locality is on the two branches of Caney Fork Creek, a tributary to Shot Pouch Creek, near the middle of the eastern margin of Cannelton Quadrangle. Only in the southeastern exposures is the full thickness revealed.

The Renault limestone occurs entirely around the Western Coal Field of Kentucky and continues into Indiana. East of the Cincinnati Arch it extends along the western escarpment of the coal fields in Kentucky and of the Cumberland Plateau in middle Tennessee into Alabama.

Thickness. The thickness of the Renault in both regions of outcrop is estimated as about 60 to 70 feet, but it was not possible to secure good measurements within

5. Stuart Weller. The Chester Series of Illinois, the Journal of Geology, Vol. XXVIII, 1920, p. 285.

the area. Variations in thickness may be expected because of the erosional disconformities at the top and bottom.

Topography. The Renault is exposed mainly on moderately steep slopes and commonly in low bluffs. The big spring at Tousey comes out from under a bluff of Renault limestone. In the sub-oval fault block between Tousey and the eastern margin of the quadrangle, some of the largest sinkholes within the area are developed in the Renault. Renault commonly weathers into smooth rounded forms as does the Ste. Genevieve.

Lithologic Characters. The Renault is similar in lithologic character to the upper portion of the Ste. Genevieve and these two formations can be separated with certainty only by paleontologic means. It is hard, medium to thick-bedded with thin shale partings and commonly as at Sample Station on Sinking Creek, just east of the margin of Cannelton Quadrangle, it includes shale beds of considerable thickness. The texture is dense to coarsely crystalline with conspicuous oolitic beds near the top, the oolites probably being more numerous than in the Ste. Genevieve. Chert is essentially lacking. Most of the limestone breaks with a conchoidal to splintery fracture. The color is light to bluish gray with some beds weathering almost white. Fossils are not numerous except in the thin shale

partings, which may be crowded with certain species. The Renault residium is a soft red clay, similar to the residual clay from the Ste. Genevieve.

Stratigraphic Relations. The possibility of a disconformity at the base of the Renault has already been considered in connection with the stratigraphic relations of the Ste. Genevieve. The contact of the Renault with the overlying Bethel sandstone presents a splendid example of an erosional disconformity. In the cliffs on Caney Fork Creek the hard gray limestone of the Renault meets the coarse, yellow, massive sandstone of the Bethel abruptly in an undulating contact line. The same condition seems to exist in the more southern areas of outcrop, although it is not so evident there. On Sinking Creek, a short distance to the east of Cannelton Quadrangle, there is evidently a considerable thickness of calcareous shale belonging to the Renault, between the top of the limestone and the base of the sandstone.

Correlation. The correlation of the Renault limestone in the Ohio Valley has been fully discussed in several bulletins of the Kentucky and the Illinois Geological Surveys⁶.

6. Stuart Weller, Kentucky Geological Survey, Series 6, Vols. 4, 10, 26, 1921-27. Illinois State Geological Survey, Bulletin No. 41, pp. 150-159, 1920.
J. Marvin Weller, Kentucky Geological Survey, Series 6, Vol. 28, 1927.
A. H. Sutton, Kentucky Geological Survey, Series 6, Vols. 31 and 42, 1929 and 1931.

Paleontology. No good fossil localities were observed in the Renault within the area, but a few species were collected from thin shale beds in a railroad cut one mile east of Sample Station in Breckinridge County. Plates of the characteristic crinoid Talarocrinus are sparsely distributed through the limestone and at the railroad cut the crinoid plates occur in the shale partings. These Talarocrinus plates serve to distinguish the Renault from the Platycrinus beds of the Ste. Genevieve. The fossils of the following brief list came mainly from the railroad cut mentioned above but a few of them are from the southeastern corner of Fordsville Quadrangle.

Composita trinucleus Hall
Spirifer breckinridgensis Weller
Spirifer leidyi N. and P.
Diaphragmus elegans N. and P.
Girtyella indianensis Girty
Phillipsis sp.
Talarocrinus sp.
Agassizocrinus conicus Owen and Shumard
Syringopora sp.
Echinoid spines

Bethel Sandstone

Name. The Bethel Sandstone was named by Butts⁷ from the exposure at Bethel School, three and one-half miles west of Marion, in Crittenden County, Kentucky.

7. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, p. 63, 1917.

Distribution. The distribution of the Bethel, like that of the Ste. Genevieve, Renault, and Paint Creek, is limited to a few small areas within the fault blocks in the southeastern corner of Fordsville Quadrangle and to the lower slopes of a few valleys in the middle portion of the eastern margin of Cannelton Quadrangle, where deep erosion in conjunction with the regional dip exposes the lower Chester. The thinness of the sandstone and the fact that it usually stands in vertical cliffs make the area of outcrop exceedingly small.

Through cartographic errors the outcrops of Bethel within the sub-oval fault block east of Tousey and along both sides of Spring Fork, south of Tousey, do not appear on the published map of Fordsville Quadrangle.

Thickness. At the line between Cannelton and Hardinsburg Quadrangles on Caney Fork Creek, the Bethel has a thickness of 40 feet exposed in a vertical cliff of massive sandstone resting directly on Renault limestone. Farther up Caney Fork the thickness is somewhat less. In the southeastern fault zone exposures, the Bethel comprises only 20 feet of yellow, loosely consolidated sandstone.

Topography. Nearly all the exposures of the Bethel in Cannelton Quadrangle are in the form of vertical cliffs 20 to 40 feet high. Since the outcrops are all near the bottoms of the valleys, the opposing cliffs are so close to-

gether that they form narrow gorges or canyons with narrow terraces above. In the southwestern exposures, the formation is thinner and less resistant, producing less precipitous outcrops.

Lithologic Characters. The Bethel is the lowermost of the several important sandstone formations in the Chester Series of Fordsville and Canneltown Quadrangles. Wherever exposed, it is uniformly a medium grained, white to yellowish brown, thick to massively bedded, quartz sandstone. Cross-bedding occurs locally. The weathered sandstone is yellowish-brown. This is the "Barlow" or "Bethel" oil sand of the drillers and is the reservoir from which the petroleum is coming at Victoria and several other localities. All prospect holes in unproven territory should be drilled at least to this horizon.

The origin of the Bethel sand is unknown, but it probably was derived from one or more of the older sandstones of the Mississippi Valley.

Stratigraphic Relations. The disconformable relations of the Bethel sandstone with the underlying Renault limestone have been discussed. The stratigraphic relations of the formation with the overlying Paint Creek are nowhere clearly shown, but in some localities there is a shale between the sandstone and the limestone while elsewhere the shale seems to be absent. Although the conditions at the contact are

not clear, it is highly probable that there is at least a local disconformity at this horizon.

Correlation. Because of the practical absence of fossils in the Bethel sandstone, the correlation of the formation must depend upon its position in the stratigraphic series between the fossiliferous Renault and Paint Creek limestones which can be correlated over long distances. Although the Bethel is absent in Edmonson County and adjoining territory, there can be no doubt that the sandstone which occurs between the Renault and Paint Creek in Fordsville and Cannelton Quadrangles is the same as the Bethel farther west in Kentucky and Illinois.

Paleontology. Like the Chester sandstones generally, fossils are rare in the Bethel and none were observed in this area. The problem of identification of sandstones in the Chester Series resolves itself into the determination of the enclosing limestones.

Paint Creek Limestone

Name. The Paint Creek Limestone was named by Weller⁸ from exposures along Paint Creek in Monroe County, Illinois. From this locality the formation has been recognized and

8. Stuart Weller. Stratigraphy of the Chester Group in Southwestern Illinois, Illinois Academy of Science, Trans. Vol. 6, p. 125, 1914.

mapped continuously around the entire Western Kentucky Coal Field.

Distribution. The Paint Creek formations are exposed in a few small areas in the zone of folding and faulting in the southeastern corner of Fordsville quadrangle. One of these exposures is an inlier or window produced by folding and erosion just south of the fault zone. Another exposure just north of the main fault on Short Creek is too small to show on the map. All the other outcrops are within the fault blocks.

In Cannelton Quadrangle, the top of the formation is exposed in the upper part of the valley of Clover Creek, while the full thickness crops out in the valleys of the western tributaries of Shot Pouch Creek and in the valley of Sinking Creek. The outcrop doubtless continues beneath a thin veneer of alluvium along the Ohio river bluff above Stephensport and into Hardinsburg Quadrangle. The upper fifteen feet of the formation is well exposed on Highway 60 near the bridge across Hites Run. At this point the Productus bed, crowded with well preserved shells, is observed. At Stephensport the lower Paint Creek limestone is exposed at the ferry landing.

Thickness. The average thickness of the Paint Creek in the Cannelton and Fordsville quadrangles is about 70 feet. There is probably little variation from this thickness.

Topography. The usual low position of the Paint Creek in the topography and its relatively non-resistant character cause it generally to form terraces on the steep slopes of valley sides. Locally the limestone beds produce low bluffs and its shale beds favor creeping and slumping of blocks of the overlying Cypress sandstone.

Lithological Characters. The Paint Creek is generally composed of three beds of soft, dark blue shale and two beds of medium bedded, bluish gray limestone all of varying thickness. The basal shale is as much as six feet thick in some localities but is lacking in others. The lower limestone member is the thicker, being locally as much as 35 feet. It is light to bluish gray in color, dense to finely crystalline, with some oolitic beds. The middle blue to green shale member, slightly arenaceous near the top, is as much as 24 feet thick locally. The upper limestone member is commonly about eight to twelve feet. It is thick bedded, bluish, slightly crinoidal and fossiliferous. The upper part of this member contains the Productus bed which is a conspicuous feature of the upper part of the Paint Creek at many localities in the Ohio Valley. In the few places where the top of the Paint Creek and its contact with the Cypress sandstone are well exposed, about six feet of dark blue or black fissile shale, with disc-like concretions occurs between the upper limestone and the base of the sandstone.

Stratigraphic Relations. The uncertainty of a disconformity below the Paint Creek was brought out in the discussion of the Bethel sandstone. The contact between the Paint Creek and the overlying Bethel was observed in only a few places because of the covering of loose rock debris, but in those places there is little evidence of a disconformity, although the dark shale of the Paint Creek changes rather abruptly to sandstone. If there is a disconformity at this contact, it is slight.

Correlation. Although paleontological data are meagre, the stratigraphic position of the formation between the Bethel and the Cypress sandstones and the relations of these sandstones to the Renault and the Golconda is sufficient to justify its correlation with the Paint Creek of Southern Illinois and Western Kentucky.

Paleontology. The shale beds of the Paint Creek formation have nowhere been found to be fossiliferous, but the limestone beds everywhere contain organic remains, although most of them are too poorly preserved to be recognizable. The only collection made was from the Productus beds at the top of the upper limestone member. The number of species represented in these beds is small, but the number of individual Productus shells, especially Productus inflatus, is enormous and they are well preserved.

The following brief list of fossils is from the productus bed on Hites Run.

Productus inflatus McChesney
Productus sp.
Spirifer increbescens Hall
Spiriferina transversa McChesney
Spiriferina spinosa N. and P.
Composita subquadrata Hall

Cypress Sandstone

Name. The Cypress sandstone was named by Engleman⁹ from Cypress Creek in southwestern Johnson and Union counties, Illinois. It is the same as the Big Clifty sandstone of Norwood¹⁰, but the name Cypress has priority and should be retained.

Distribution. In the southeastern part of Fordsville Quadrangle there are only two districts in which the Cypress is exposed and the areas of exposure are small. One of these districts is in the zone of faulting and folding in the southeastern corner of the quadrangle and the other is in the bluffs of Rough River near the point of its entrance into the Quadrangle. A cartographic error is responsible for the reversal of the map symbols of Cypress and Golconda in the

9. Henry Engleman, The Lower Carboniferous System as Developed in Southern Illinois, St. Louis Acad. of Science Trans. Vol. 2 1863, p. 189.

10. C. J. Norwood, Report on the Geology Adjacent to the Louisville, Paducah, and Southwestern Railroad, Kentucky Geological Survey, New Series, Vol. 1, 1876, p. 366.

small area bounded by "The Bend" in Rough River and the eastern margin of the quadrangle.

An isolated outcrop of massive Cypress sandstone appears one mile north of Olston in the southwestern part of Fordsville Quadrangle where Caney Creek cuts through the top of the great anticline which lies to the south of the fault zone.

In Cannelton Quadrangle, the Cypress crops out along the sides of the valley of Clover Creek and its tributaries above the junction of Clover Creek and Hites Run. The full thickness of the Cypress is exposed in the upper reaches of Clover Creek and Hites Run. Sinking Creek and all its tributaries, lying within the Cannelton Quadrangle, exhibit outcrops of Cypress sandstone in their valley sides and the outcrop continues along the Ohio River bluff for two miles above the mouth of Sinking Creek. Regional dip and concave valley profile bring the Cypress to the surface in the head of Bull Creek. The sandstone shows in the base of the hills just above the alluvium in the northeastern corner of Cannelton Quadrangle.

The Cypress, being more persistent and somewhat less variable in character than the other Chester sandstones, is more easily traced around the margin of the Western Kentucky Coal Fields and into southern Indiana and Illinois. It is worthy of note that the Cypress is the sandstone which is so conspicuous in the hills in the Mammoth Cave area. The

Cypress exhibits its more shaly, less resistant phase at the base of the hill on Highway 60, near the head of Hites Run.

Thickness. The Cypress varies between 50 and 65 feet in thickness in Cannelton Quadrangle. Farther south, in Fordsville Quadrangle, it is thinner and ranges from 35 to 45 feet.

On Caney Fork Creek in the eastern part of Cannelton Quadrangle the Cypress reaches its maximum observed thickness of 65 feet. The following thicknesses exist in the localities named: Stephensport, 50 feet; Highway 60, near the head of Hites Run, 50 feet; on the east side of Clover Creek on the Balltown-Hardinsburg road, 62 feet; on Clover Creek three and one-half miles southeast of Cloverport, 50 feet; in "The Bend" on Rough River, 40 feet; in the fault zone east of Tousey, 35 feet. The thickness north of Olaton, could not be determined because the lower portion of the section is covered with alluvium.

Topography. The Cypress sandstone is one of the principal cliff and rock house producing formations of this part of the State, a fact which was discovered by the aborigines, mute evidence of whose occupation can be observed beneath most of the rock houses today.

Within this area, the Cypress occupies an inferior position in the topography and for this reason its usual expression is in the form of cliffs, rock houses, bluffs, steep

slopes, gorges, miniature waterfalls, and narrow terraces. However, near the middle of the eastern part of Cannelton Quadrangle, regional dip brings it high enough to form rolling uplands of considerable extent between the stream gorges. Farther east, in Hardinsburg Quadrangle, it vies with the Hardinsburg Sandstone as a flat former.

Lithologic Character. The Cypress is locally a massive sandstone formation but generally it has much thin bedded, shaly sandstone both above and below a more massive middle portion. Beds of shale at both top and bottom are not uncommon. Like all the other Chester sandstones in this region, the Cypress varies rapidly in character both vertically and laterally. A good example of this variation appears in the vicinity of Stephensport.

At Stephensport, the Cypress is composed of a lower portion of 40 feet of blue arenaceous shale and an upper portion of 10 feet of medium grained, thin bedded sandstone which weathers into thin flakes. In the river bluff one mile northeast of Stephensport the upper 45 feet of the formation is exposed as a medium bedded to massive, medium grained, brown sandstone. Only four miles south of Stephensport it is 65 feet thick and all medium bedded to massive sandstone. The Cypress is massive and about 40 feet thick on Rough River. In the fault zone in the southeastern corner of Fordsville Quadrangle shale occurs above and below a middle sand-

stone member, the whole being only about 35 feet thick. One mile north of Olaton the upper portion, which is the only part exposed, is massive.

The Cypress is very similar to the flaggy phases of the Hardinsburg sandstone in many of its exposures and in localities where the Hardinsburg is nearly all shale, as on Caney and Clover Creeks, three and one-half miles southeast of Cloversport, the Cypress may be mistaken for the higher sandstone, unless the lithologic character and the fauna of the overlying limestones are well known and can be observed.

The Cypress is fine to medium coarse grained, yellow to light brown with iron oxide cement. Crossbeds and ripple marks are quite common, suggesting deposition in shallow water.

The Cypress sandstone is the "Jackson Oil Sand" of the drillers and is a productive horizon in several localities in this part of Kentucky. The coarser grained and less indurated portions of the sandstone should furnish good reservoirs for the accumulation of oil.

Stratigraphic Relations. The stratigraphic relation of the Cypress sandstone with the underlying Paint Creek formation has already been considered. The contact between the Cypress sandstone and the overlying Golconda formation has been observed in many places and everywhere there seems to be a complete transition in lithology from the sandstone to the

shale beds in the basal part of the Golconda formation, a condition which suggests the absence of any stratigraphic break.

Correlation. The identity of this sandstone is established by tracing its outcrop and by its stratigraphic position between the Paint Creek and Golconda limestones which can be identified by paleontological means.

Paleontology. No fossils definitely identified as such were observed in the Cypress. However, at the bridge across Beech Fork of Clover Creek, some peculiar rock bodies occur at the top of the sandstone. Some of them are separate from the solid rock and are double spindle shaped, tapering toward either end, about an inch in diameter and six inches long. Others are longer, not so thick, and of more uniform size throughout their length. The latter are criss-crossed in heterogenous fashion on the surface of the sandstone ledges as if they had been made of mud and laid on the rock while they were yet soft. They look somewhat like the casts of roots but may represent the contents of the gastric cavities of huge worms or of some other soft bodied animals.

Golconda Limestone

Name. The Golconda limestone was first named in print by Butts¹¹, although Weller and Ulrich had given it

11. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917, p. 91.

this name at an earlier date from the excellent exposures in the Ohio river bluffs a short distance above the town of Golconda, Illinois.

Distribution. The Golconda formation is exposed in the Fordsville Quadrangle in several localities along the Rough River zone of folding and faulting from Olaton eastward to the margin of the area. Around "The Bend" of Rough River and on the head of Pleasant Run Valley southeast of Falls of Rough it again comes to the surface. Northward it is not exposed again until the head of Clover Creek in the northeastern corner of Fordsville Quadrangle.

The Golconda limestone, because of a broad, low westward plunging anticline, crops out as far west as Cloverport in the middle of Cannelton Quadrangle. With the exception of Tar Creek, it appears along Clover Creek and all its tributaries. It is also exposed throughout Sinking Creek drainage, in Bull and Goehagen Creek valleys, and along the hills adjoining the alluvial plains of the Ohio River, except those between the mouth of Bull Creek and Addison where a shallow, westward plunging syncline carries the formation below drainage. The total area of outcrop of the Golconda in Fordsville Quadrangle is small, but it underlies a large portion of the eastern one-third of Cannelton Quadrangle.

An excellent exposure of the Golconda formation occurs at the quarry near the head of Hites Run on Highway 60.

The full thickness of the limestone with the overlying Hardinsburg shale is exposed in the quarry and the sandstone and shale members may be seen along the road below the quarry.

Thickness. Like all the other Chester formations the Golconda varies considerably in thickness. Measured sections vary from 50 to 75 feet with 60 feet a fair average. The following measurements are exact: at the quarry in the bluff of the Ohio River, one mile northeast of Stephensport, 53 feet; on Highway 60 near the head of Hites Run, 73 feet; on Caney Creek, three and one-half miles southeast of Cloverport, 61 feet; along the Balltown-Bardinsburg Road on the east side of Clover Creek, 69 feet; in "The Bend" of Rough River, 56 feet; on Wild Cat Hill, one mile north of Olaton, 75 feet.

These widely scattered sections seem to indicate that the variations in thickness are local and that there is no tendency toward thickening or thinning in any particular direction.

Topography. The Golconda expresses itself in the topography as a non-resistant formation between two more or less resistant sandstones. Generally it crops out on steep or moderately steep slopes and in places the limestone member is exposed in vertical bluffs along streams and in steep valley sides. It is an easily soluble limestone and sink holes in it are of common occurrence. They are generally of

small size and frequently are developed through the overlying Hardinsburg sandstone.

The contact of the upper limestone member and the lower shale member is a good horizon for springs fed by water gathered by the Hardinsburg sandstone and carried down to the impervious shale bed along joints and solution channels in the limestone. Where the shale is thick and forest and talus covering lacking numerous rapidly eroding gullies develop.

Lithologic Character. The Golconda is composed of varying thicknesses of limestone, shale, and sandstone, the proportions of the different materials occurring usually in the order named. Locally there is a thin bed of crinoidal limestone at or near the base of the formation but generally this is lacking and the lower member of the formation is a thick bed of varicolored shale with green and red hues predominating. This lower shale member is rarely thinner than fifteen feet and locally it may reach a thickness of forty feet.

Quite commonly the basal shale member becomes more or less arenaceous toward the top and in some localities develops into a thin bedded, hard, fine grained shelly or flaky sandstone. At the quarry on Highway 60, near the head of Hites Run, this sandstone is six feet thick. On a side road one-half mile southwest of this point and in the head of Caney Fork Creek, 4 miles to the north, it may be thicker.

On Hites Run the change from sandstone to the overlying limestone is so abrupt that it suggests a local disconformity within the Golconda formation.

Above the lower shale or sandstone, lies what is generally the thickest ledge of limestone above the Renault, although locally the lower limestone member of the Glen Dean equals it in thickness. The light color of the weathered surface of the Golconda limestone is a characteristic feature in which it bears quite a contrast to the Glen Dean and the upper Chester limestones which are usually of darker hue. However, there is usually much yellow or brown argillaceous limestone near the top of the Golconda.

The bedding varies from medium to thick, approaching massiveness with little or no shale partings. It ranges in texture from dense to coarsely crystalline, being coarser than the Glen Dean. Oolitic beds are quite common from the middle upward, although this feature is not as conspicuous as in some of the lower limestones. This is another point of difference between Golconda and Glen Dean for oolites are rare in the Glen Dean.

The Golconda limestone especially near its top, includes considerable quantities of dark tabular oolitic chert, which has resulted from the silicification of parts of certain limestone beds. It breaks up into angular fragments and weathers white. Since chert is comparatively rare in the limestones of this region it may be of value in identifying

the Golconda. Most of the fossils in the Golconda occur in the upper layers of the limestone where loose weathered rock is commonly crowded with the remains of marine life.

The thick ledge of Golconda limestone generally makes contact directly with the overlying Hardinsburg sandstone but locally there are interstratified beds of shale or limestone and shale between the limestone and sandstone.

The following resumé of some of the differences in lithologic characters of the Golconda and Glen Dean are given because they are usually sufficient for distinguishing between the two formations. The Glen Dean nearly always has its thick shale member at the top and its thick limestone ledge in the lower part, this order being reversed in the Golconda; the Golconda is almost invariably of lighter color than Glen Dean; Golconda commonly contains oolites, whereas in the Glen Dean oolites are rare; Golconda exhibits weathered chert on most outcrops, chert is uncommon in the Glen Dean; Glen Dean contains no sandstone, whereas the Golconda has locally a thin, shelly, flaky sandstone member near the middle. Some beds of the Golconda are more coarsely crystalline than any beds in the Glen Dean and Golconda shales are more commonly red or reddish than are those of the Glen Dean.

The following widely scattered, carefully measured sections will give a good idea of the Golconda.

Section in a quarry in the Bluff of Ohio River, one mile above Stephensport:-

	Thickness
Hardinsburg, Arenaceous shale and sandstone	
Limestone, light color, thick bedded to massive, oolitic beds in the upper two-thirds	34 ft.
Shale, soft, greenish blue, calcareous	13 ft.
Shale, soft, red	6 ft.
Cypress sandstone	

Section at quarry near the head of Hites Run on Highway 60.

Hardinsburg sandstone, shaly and shelly	
Limestone, thin to thick bedded, bluish and dense in the lower part, oolitic beds and lighter color from middle upward, many fossils near the top	20 feet
Sandstone, fine frained, thin bedded shelly or flaky, hard and dense	6 feet
Shale, soft, red and blue	38 feet
Cypress sandstone, thin bedded, argillaceous	

Section on Caney Creek, three and one-half miles southeast of Cloverport.

Hardinsburg, sandstone, thin bedded, flaky, argillaceous	
Limestone, medium to thick bedded, light colored, crinoids, penetremites, corals	45 feet
Shale, red and green, calcareous	16 feet
Cypress sandstone, thin bedded, shelly, flaggy.	

Section along Balltown-Hardinsburg Road on east side of Clover Creek.

Hardinsburg sandstone, thin bedded, flaggy	
Limestone	3 feet
Shale	4 feet
Limestone, light color, medium to thick bedded	34 feet

Shale, red and blue containing thin flakes of sandstone near the top	28 feet
Cypress sandstone, yellowish brown, medium grained, medium to thick bedded	

Section on the east side of "The Bend" on Rough River.

Hardinsburg sandstone, thin to medium bedded, medium to fine grained, flaggy	
Shale, blue	1 foot
Limestone, medium to thick bedded, light gray, crystalline, partly crinoidal, not very fossiliferous	30 feet
Shale, red and blue	24 feet
Limestone, light gray, crinoidal	1 foot
Cypress sandstone, medium grained, nearly white when fresh, light brown when weathered.	

Section on Wild Cat Hill, one mile north of Olaton.

Hardinsburg Sandstone, thin bedded, flaggy.	
Limestone, medium to thick bedded, light gray, some tabular oolitic chert	40 feet
Shale, soft, red and blue	35 feet
Cypress sandstone, massive	

Stratigraphic Relations. Evidently the Golconda limestone overlies the Cypress sandstone without a stratigraphic break. The relation with the overlying Hardinsburg sandstone is not so clear but the fact that, wherever this contact has been observed, the change in the character of the materials is very abrupt is significant. A loose boulder of limestone conglomerate observed on Lick Creek, three miles east of Glen Dean, seemingly came from this contact. In the great majority of places where the contact has been observed the change is directly from thick bedded limestone to sandstone or sandy shale. At a few places there is a calcareous shale of Golconda type between the limestone and the sandstone.

which still further strengthens the belief that the Golconda was subjected to more or less differential erosion before the deposition of the Hardinsburg.

Correlation. The Golconda formation is a distinct unit in the Chester section at all places where it has been observed to the west and south. It extends completely across southern Illinois and its outcrops surround the Western Kentucky Coal Basin, passing in a northwestward direction into southwestern Indiana. It has not been definitely recognized on the eastern flank of the Cincinnati Arch.

Paleontology. The upper beds of the Golconda limestone are highly fossiliferous in some localities in Fordsville and Cannelton Quadrangles, Archimedes, Pentremites, and Crinoidae being the most plentiful. No extensive collection of Golconda fossils was attempted, but the following fauna collected in the two quadrangles is characteristic of the region.

Archimedes lativolvus Ulrich
Archimedes terebriformis Ulrich
Archimedes compactus Ulrich
Pentremites pyriformis say
Pentremites Godoni De France
Pentremites pyramidatus Ulrich
Prismopora sp.
Fistulipora sp.
Fenestella sp.
Crinoid stems
Cyathocrinus sp.
Echinoid spines
Zaphrentes pellaensis Worthen
Spirifer leidyi Norwood and Patton

Spiriferina transversa McChesney
Cliothyridina sublamellosa Hall
Girtyella indianensis Girty
Martinia sp.
Composita sp.

Hardinsburg Sandstone

Name. Hardinsburg, the county seat of Breckinridge county, from which Butts¹² named the Hardinsburg sandstone, is located two miles east of the southeastern margin of Cannelton Quadrangle.

Distribution. The broad, flat or gently rolling upland produced by the resistant Hardinsburg in its typical development extends into the southeastern portion of Cannelton Quadrangle, and into the northeastern corner of Fordsville Quadrangle. The sandstone continues as a flat and terrace former throughout the eastern tier of rectangles in Cannelton Quadrangle. Its area of outcrop in Fordsville Quadrangle is limited to the northern portion of McQuady Rectangle, to two small areas near the town of Glen Dean, to the region between "The Bend" on Rough River and Locust Hill Fault, and to certain areas along the Rough River Fault Zone. It forms a cap for most of the dome one-half mile southwest of Yeaman, in which the slope of the land surface and the dip of the rocks almost coincide. Its most western outcrop in Cannelton Quadrangle is at Cloverport, where it is exposed along Clover

12. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917, p. 96.

Creek, in the bed of a small stream in the eastern part of town and in the clay pit of the Murray Roofing-Tile Company.

The Hardinsburg is brought to the surface as an inlier by a combination of regional dip and concave stream profile, at Glen Dean. On Highway 60, the Hardinsburg sandstone is well displayed at the western limits of the town of Hardinsburg. In the quarry beside the highway, about one and a half miles southeast of Hites Run church, the shaly, flaky Hardinsburg is exposed at the top of the quarry.

Thickness. The Hardinsburg varies in thickness between nineteen and forty feet.

Topography. The Hardinsburg sandstone is responsible for extensive, nearly level flats and terraces in the region of Hardinsburg and in the eastern one-third of Cannelton Quadrangle. Even where it is mostly shale as well as where it is thick sandstone, it forms surprisingly broad terraces and flats. The sandstone forms low bluffs, cliffs, and small waterfalls and rapids at the edge of flats and in hillsides. It frequently rims sinkholes into the underlying Golconda limestone. Elsewhere, where the formation is mostly shale, it does not express itself in the topography.

Lithologic Characters. In the vicinity of Hardinsburg the formation consists of a coarse grained, massive bed about ten feet thick in the middle with ten feet of some-

what thinner bedded rock below and shaly sandstone above. The usual condition of this sandstone is thin bedded and flaggy or flaky, rather fine grained, hard and somewhat argillaceous and ferruginous.

The Hardinsburg varies rapidly in character both laterally and vertically. In some localities it is as thin as twenty feet and composed of soft, arenaceous shale. Elsewhere it may be as much as forty feet thick and composed almost entirely of medium bedded to massive sandstone. In general it grows thinner and more shaly toward the south and southwest and thicker and more sandy toward the northeast.

In the Caney Creek section, three miles southeast of Cloverport, it has a total thickness of nineteen feet, including six feet of flaky calcareous sandstone at the base, six feet of blue shale with thin flakes of sandstone in the middle, and seven feet of blue arenaceous shale at the top. This section probably represents the minimum thickness and poorest development of the Hardinsburg within the area.

Locally, the Hardinsburg contains limestone. On Beech Fork of Clover Creek, one-half mile northwest of Taul School, there is a thickness of about twenty-five feet of thin bedded, shelly to thick bedded sandstone with three feet of contorted, cross bedded and probably siliceous limestone near the middle. This limestone member has been observed at other places in the Clover Creek drainage.

The lower ten to eleven feet of clay in the clay pit

of the Murray Roofing-Tile Company, northeast of Cloverport, belongs to the Hardinsburg. In the bluffs of Clover Creek, just above the city limits of Cloverport, there is a basal bed of thin bedded, ripple marked, fine grained, flaggy sandstone grading upward into blue or greenish sandy shale with intercalated thin beds of fine grained sandstone. This is succeeded by about twenty feet of soft red and green shale with four or five feet of thin bedded, ripple marked, fine grained, flaggy sandstone at the top.

The Hardinsburg is represented by eighteen to twenty feet of shale and flaky sandstone on Wild Cat Hill, one mile north of Olaton. At the quarry in the bluff of Ohio River, one mile above Stephensport, the whole section of thirty-seven feet is plainly exposed and has been carefully measured. At the base there is from six to nine feet of blue, laminated, arenaceous shale with thin beds of sandstone intercalated in the upper half. The contact of this portion with the overlying twenty-eight feet of medium bedded to massive sandstone is undulating, but not disconformable.

In the extreme northeastern corner of Cannelton Quadrangle the Hardinsburg is about forty feet thick and composed chiefly of sandstone. Ripple marks and crossbedding abound in the Hardinsburg. The sediments were deposited on an uneven surface in shallow water by currents of varying forces and directions.

Stratigraphic Relations. The disconformity between the Hardinsburg sandstone and the underlying Golconda limestone is discussed in the paragraph on the stratigraphic relations of the Golconda.

The Hardinsburg is overlain with apparently perfect conformity by the Glen Dean limestone as indicated in the discussion of the stratigraphic relations of the Glen Dean formation.

Correlation. The position of this sandstone between the easily recognized Golconda and Glen Dean limestones is sufficient to make its correlation certain and its recognition easy.

Paleontology. Fossils are very rare in the Hardinsburg; the only ones observed being a few widely scattered impressions of brachiopods in residual blocks of the sandstone.

Glen Dean Limestone

Name. The village of Glen Dean, for which Butts¹³ named the Glen Dean limestone, is situated on the Louisville and Nashville Railroad in the eastern part of Fordsville Quadrangle in Breckenridge County, Kentucky.

Distribution. This formation is exposed continuously

13. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917, p. 97.

east and west along the Rough River Fault zone across the southern portion of Fordsville Quadrangle and except where it has been removed by erosion along drainage lines, it crops out throughout the north -- south length of the two quadrangles. It covers a large portion of the surface east of a line drawn north and south through the middle of the area.

Like several of the other formations, the Glen Dean first appears in the valley bottoms in the western margin of its area of outcrop and gradually rises higher on the slopes in the up dip direction until it is found only in the tops of the highest hills and ridges in the eastern portion of the area. Good exposures are numerous and the characteristic fossils are plentiful and widely distributed making the Glen Dean an easily recognized horizon and a convenient stratigraphic key bed.

The Glen Dean is possibly the most widely distributed definitely recognizable unit of the Chester Series. It extends from east to west the entire distance from Mississippi River in southern Illinois to Virginia and from northern Kentucky to central Alabama.

Easily accessible places for the observation of the Glen Dean along Highway 60 are between the highway and the river at Little Tar Springs, at the quarry of the Murray Roofing-Tile Company at Cloverport, at the quarry now being worked by the State Highway Department, one mile east of Cloverport and in the hills one mile west of the eastern margin of

Cannelton Quadrangle.

Thickness. The total thickness of the Glen Dean formation in the two quadrangles ranges from sixty-five to one hundred feet. In Wildcat Hill, on the crest of the anticline on Caney Creek, three-fourths of a mile northeast of Olaton, the thickness is 82 feet; one-half mile northwest of Shady Grove School in Tousey Rectangle it is 85 feet and on Highway 60, two miles southeast of Hites Run Church, it is 80 feet. Just east of Lone Star School in the southeastern part of Glen Dean Rectangle of Fordsville Quadrangle the Glen Dean is 71 feet thick and at Glen Dean it is 67 feet. In the bluff of Ohio River, northeast of Stephensport, the thickness is 65 feet. On the west side of the valley of Beech Fork of Clover Creek on the Balltown Hardinsburg Road it is 65 feet, the minimum. On Caney Creek, Butts¹⁴ Section No. 23, it shows a thickness of 86 feet. In the extreme northeastern part of Cannelton Quadrangle, north of Yellow Bank Creek, it is 85 feet. The thickest and the thinnest sections, Cloverport (100 feet) and Beech Fork Creek (65 feet), are only about 7 miles apart. It seems to vary inversely with the thickness of the overlying Tar Springs sandstone.

Topography. Wherever the Glen Dean is overlain by the more resistant phases of the Tar Springs it usually crops out

14. Charles Butts, The Mississippian Series of Western Kentucky Kentucky Geological Survey, 1917, Section 23 of Plate 3.

in steep slopes, but where the Tar Springs has been removed the lower limestone member with the assistance of the resistant underlying Hardinsburg sandstone, often forms broad, gently sloping ridges and hills. The lower limestone of the Glen Dean forms the rapids or falls of Rough River at the village of Falls of Rough.

Lithologic Character. Unlike the Golconda, the thickest limestone member of the Glen Dean is near the base and the upper one-half to two-thirds of its thickness is mainly shale. This difference, persistent throughout most of the region, in vertical distribution of limestone and shale in the two formations is very helpful in distinguishing between them.

In general, the Glen Dean is composed of three shale members and two limestone members of varying thicknesses. The basal shale varies in thickness ~~from~~ three feet, as in the type locality, to 24 feet on the west side of the valley of Beech Fork of Clover Creek on the Balltown-Hardinsburg road. It is usually composed of about equal amounts of green or blue and red clay shale. Frequently small, warty concretions occur in this shale and at some places, it is quite calcareous, or marley and fossiliferous, especially near the top.

A ledge of medium to thick bedded limestone persistent throughout the area and varying in thickness from 24 feet on Beech and Caney Fork of Clover Creek to 46 feet in the quarry of the Murray Roofing-Tile Company at Cloverport oc-

curs above the basal shale. This limestone is of a nearly uniform light gray color, but locally beds are bluish and where weathered may be buff or cream colored. It varies in texture from dense to coarsely crystalline. Some of the beds near the middle of the interval are separated by thin shaly or marly partings, filled with bryozoa. The last named beds of limestone are locally siliceous and resemble sandstone. Oolites are locally present, but beds in which they form a conspicuous constituent of the rock are rare. Fossils are usually present in all the beds, the number varying laterally and vertically from sparse or nearly lacking to dense crowding. The upper part of the Glen Dean limestone is the most fossiliferous horizon in the two quadrangles.

The Glen Dean is almost chert free but dark colored, tabular chert in small quantities occurs in a few localities. The middle shale member is present over all the area even where the upper limestone member is lacking. It is nearly everywhere a soft blue shale more or less calcareous, varying in thickness between six and a half feet and twenty-three feet. At the quarry of Murray Roofing-Tile Company it is bluish gray, highly calcareous, and filled with bryozoa of the Fenestellid type. At the surface this shale, like most of the other Chester shales, weathers to a greenish blue or green color.

The upper limestone member of the Glen Dean is the most discontinuous of all. In many localities it is entirely

lacking, its place in the section being occupied by shale. In others it is represented by one or more thin, crusty, crinoidal, siliceous, highly fossiliferous beds of limestone intercalated with shale; elsewhere, as at Cloverport, it may be represented by a considerable thickness of thick bedded limestone. In the quarry of the Murray Roofing-Tile Company it is composed of four beds with a total thickness of eleven feet. The thinnest bed is 1.3 feet and the thickest 4.9 feet. Locally oolites are present as are also cross beds and sandy layers. In some localities the beds contain iron and weather to a rusty brown. Where the upper shale member is absent in the disconformity as is the case at Tar Springs, beds of the upper limestone are in direct contact with the Tar Springs.

The upper soft, blue, and red shale member of the Glen Dean is absent or nearly so, where the Tar Springs sandstone is well developed and may be as much as 26 feet thick where the Tar Springs is thin and mainly shale. It aids materially in the creeping and sliding of blocks of the overlying sandstone.

Two sections, one from the type locality, Glen Dean and the other from the locality of greatest thickness and best development of limestone, the quarry of the Murray Roofing-Tile Company at Cloverport give a good idea of the lithologic characters of the Glen Dean.

Sections at Glen Dean, Butts¹⁵, Section No. 19,

15. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917, Plate 3.

Plate 3, measured from the bed of Daniels Creek near the depot, along the road up both sides of the valley. This represents the usual character of the Glen Dean.

- g. Greenish gray sandy shale and flaky sandstone, Tar Springs.
 - f. 12 feet. Upper Glen Dean shale, blue, weathers to green, soft.
 - e. 1 foot. Upper Glen Dean limestone, light gray, crystalline, fossiliferous.
 - d. 24 feet. Middle Glen Dean, soft, blue shale.
 - c. 27 feet. Lower Glen Dean limestone, light gray, medium to thick bedded, fine to coarsely crystalline, highly fossiliferous at top.
 - b. 3 feet. Lower Glen Dean shale, soft, red and blue. There is some shale belonging to the top of the Hardinsburg here and the thickness of shale between the sandstone of the Hardinsburg and the limestone of the Glen Dean varies considerably within short distances.
 - a. 5 feet. Exposure of Hardinsburg sandy shale and flaggy sandstone in the bed of the creek.
- Total thickness of Glen Dean in the type locality, 67 feet.

Section in the quarry of the Murray Roofing-Tile Company at Cloverport. This represents the maximum thickness and best development of the Glen Dean within the two quadrangles.

- g. 7 feet. Tar Springs sandstone, yellowish brown, thin bedded, argillaceous.
- f. 14.5 feet. Upper Glen Dean shale, bluish gray, brittle.
- e. Upper Glen Dean limestone:
 - 3rd-6 feet. Light gray, oolitic thick bedded limestone, in two beds with a thin sandy parting.
 - Lower bed 1.3 feet thick and upper one 4.7 feet.
 - 2nd-1.5 feet. Bluish, gray, argillaceous limestone.
 - 1st-3.5 feet. A single, thick bed of light gray limestone.
- d. 6.5 Middle Glen Dean shale, bluish gray, highly calcareous and filled with fronds of bryozoa.

c. Lower Glen Dean Limestone:

- 6th. 16 feet. Thick bedded to massive light gray limestone somewhat crystalline and granular in appearance.
- 5th. 3.5 feet. Thinner bedded, bluish sandy limestone with thin beds of blue shale intercalated.
- 4th. 6 feet. Light brown or cream colored oolitic limestone.
- 3rd. 18.8 feet. Thick bedded, bluish gray, fairly dense, slightly fossiliferous limestone.
- 2nd. 1 foot. Gray, calcareous shale, filled with bryozoa.
- 1st. 0.5 foot. Crusty, brown, argillaceous limestone.
- b. 22 feet lower Glen Dean shale. Red and green with many small warty concretions which weather white.
- a. Hardinsburg. Arenaceous shale and flaky sandstone. Total thickness of Glen Dean in Murray Roofing-Tile Company Quarry, 100 feet.

Stratigraphic Relations. The Glen Dean limestone appears to overlie the Hardinsburg sandstone with complete conformity although the contact between these two formations rarely is well exposed. In localities where the uninterrupted section has been observed no positive evidence of disconformity has been established, although the change in the character of the sediments is often somewhat abrupt. Commonly, the Hardinsburg becomes somewhat shaly at the top and gradually merges with the lower Glen Dean shale making it practically impossible to locate the contact exactly. The best example of this is shown in the clay pit of the Murray Roofing-Tile Company, just north of Cloverport where the clean, unobstructed face of thirty-two feet of red and green shale shows between the lower Glen Dean limestone and the shaly, flaky sandstone of the lower portion of the Hardinsburg for-

mation. It is certain that some of the face of the clay pit is Hardinsburg and that some of it is Glen Dean, but it is impossible to locate the contact exactly. In this study the contact in the clay pit was placed twenty-two feet below the base of the limestone on the basis of the percentage of sand in the shale.

There is undoubtedly a disconformity at the top of the Glen Dean. At a number of localities within the area, the overlying sandstone rests directly upon the uneven surface of a limestone or a soft shale bed of the Glen Dean, the change from limestone or shale to sandstone being abrupt, with no suggestion of transition beds. Furthermore, the varying thickness of the Glen Dean formation suggests an erosion interval between the deposition of it and the next succeeding formation, during which there were varying amounts of erosion from different portions of the Glen Dean surface.

Correlation. Nearly all the fossils and lithologic characters known to be characteristic of the Glen Dean in its wide distribution over Kentucky and southern Illinois occur in this region. Since this is the type locality of the Glen Dean, the burden of correlation is thrown upon the workers in other areas.

Paleontology. The lower Glen Dean limestone is highly fossiliferous and the beds of the upper limestone, locally, are crowded with fossils. Exhaustive search for fossils was rarely made, but the most readily available

material was gathered from many localities. From this material the following brief list was made. Most of the fossils of this list were collected at or near the type locality.

Pentremites spicatus Ulrich
Pentremites pyramidatus Ulrich
Pentremites Cherokeeus Hall
Pentremites pyriformis Say
Pentremites brevis Ulrich
Pterotocrinus acutus Wachamuth and Springer
Pterotocrinus depressus Lyon & Cassady
Agassizocrinus conicus Owen & Shumard
Eupachyocrinus sp.
Archimedes swallowanus Hall
Archimedes laxus Hall
Archimedes sublasix Ulrich
Archimedes sp.
Tabulipora sp.
Lyropora sp.
Lyropora quincincialis Hall
Polypora sp.
Rhombopora sp.
Prismopora serrulata Ulrich
Chilotrypa hispida Ulrich
Meekopora clausa Ulrich
Bellerophon sp.
Trypolphyllum spinulosum M.E. & H.
Spiriferina spinosa N. and P.
Orthoruchia sp.
Composita trinolea Hall
Composita subquadrata Hall
Clotnyrodina sublamellosa Hall
Girtyella indianensis Girty
Productus sp.
Phillipsia sp.

Of the fossils, above listed, Archimedes laxus, Prismopora serrulata, Pentremites spicatus, Pterotocrinus depressus, and Pterotocrinus acutus are highly diagnostic of the Glen Dean limestone, and occur so commonly that a glance over any good Glen Dean outcrop will usually reveal two or more of these species. The most useful single species is Prismopora serrulata.

Tar Springs Sandstone

Name. This is the area of the typical development of the Tar Springs sandstone. The locality for which Owen¹⁶ named it is three miles south of Cloverport in Cannelton Quadrangle, Breckinridge County, Kentucky. Several small springs at this point issue from the sandstone at its contact with the underlying Glen Dean formation and yield a little petroleum which, after exposure and evaporation, leaves a tarry residuum, hence the name. Little Tar Springs, in the bluff of Ohio river on Highway 60, two miles west of Cloverport, is very similar to the type locality.

Distribution. The Tar Springs sandstone extends throughout the upper Chester terraines of most of western Kentucky and southern Illinois and the writer has observed a similar sandstone at the same horizon in eastern Kentucky as far north as northeastern Pulaski County. In Fordsville and Cannelton Quadrangles the Tar Springs formation crops out continuously along the eastern margin of the Pottsville covered area and in the hills, ridges and flats to the eastward. It was involved in the faulting and folding throughout the Rough River Fault zone where numerous outcrops exist. Its most extensive areas of outcrop are in the type locality, along Tar Creek, in the region of McQuady, and along the ridge road between Cloverport and Stephensport.

16. D. D. Owen, Second Report of the Geological Survey in Kentucky, 1857, p. 87.

Thickness. The Tar Springs reaches a maximum thickness of 70 feet, in its massive sandstone phases, exhibited on Tar and Rock Lick Creeks. In certain localities in the southeastern part of the area, it is as thin as 25 feet with 50 feet being a fair average thickness for the formation.

Topography. Due to its resistant character and to its superior position in the section, the Tar Springs sandstone is the greatest terrace and flat forming hard rock formation in the area except in the middle part of the eastern portion of Cannelton Quadrangle where a broad, low, westward plunging anticline brings the Hardinsburg sandstone up to the flat forming elevation. However, its area of outcrops is narrow when it appears low on steep hillsides in the form of shale slopes or sandstone bluffs and cliffs. The Tar Springs forms many picturesque little waterfalls in the heads of ravines and its contact with the Glen Dean is the source of many pure water springs as well as tar springs.

Differential erosion on the Glen Dean and Tar Springs formations commonly leaves the sandstone standing in vertical or overhanging bluffs, cliffs, and rockhouses whose faces are frequently etched into rock lace and lattice. Hites Falls on Rough River is formed by a ledge of Tar Springs sandstone from beneath which the shale has been sapped.

Lithologic Characters. The lithologic characters

of the Tar Springs formation are exceedingly variable, both vertically and laterally. Massive sandstone ledges 70 feet thick change to 30 or 40 feet of shale and thin bedded, flaky sandstone in surprisingly short distances. For example, at "Hotel Rockhouse", a favorite camp site for Indians and pioneers, on Rock Lick Creek one mile west of the town of Glen Dean, the Tar Springs sandstone stands in a massive cliff 50 or 60 feet high, and has a total thickness of 70 feet, but in the valley on either side of Glen Dean its outcrop is so inconspicuous that a casual observer might easily overlook it.

The basal portion of the sandstone is the most persistent, but there are localities where the sandstone is in the middle or at the top with shale occupying the remainder of the section. In many localities the sandy character practically disappears. This is especially true in the southeastern portion of Fordsville Quadrangle, where the Tar Springs ceases to be a distinct unit and blends into the basal portion of the Leitchfield formation.

Thickening and thinning are evidently the result of differences in the basal portion of the formation while the upper surface, at the close of Tar Springs sedimentation, must have been nearly level. This idea is strengthened by the persistence and nearly uniform character of the thin Menard limestone which overlies the Tar Springs, seemingly without interruption throughout the area. There is a direct

relation between the depth of erosion in the post-Glen Dean surface and the thickness and character of the overlying Tar Springs sediments. Deep post-Glen Dean erosion and maximum thickness and greatest development of massive sandstone in the overlying Tar Springs is a condition which exists in many localities. The reverse is also true. These facts lead to the conclusion that streams or currents carried the sediments into the area after slight oscillations brought the eroded Glen Dean surface below the level of base level. The first, strongest, and most continuous movement of water was along the lower channels in the Glen Dean surface. This movement was strong enough to carry and deposit sand during a part or all of Tar Springs time, while the interstream or intercurrent areas of slack water were receiving only fine sediment. Occasional shifts of current brought the coarser sand in over the finer sediments. This theory seems to explain adequately the notable variations in the character of the Tar Springs formation and may apply equally well to similar variations in some of the other Chester sandstones.

The sediments vary from soft, almost sand free shale to medium coarse grained sandstone, indurated through ferruginous cementation. No conglomeratic portions were observed. The sand grains vary considerably in size, but average medium, and are fairly well rounded. Bedding varies from very thin or laminated in the shales to massive in the sandstone with cross bedding common. The color of the shale is usually dark

to light gray, but locally it is blue, red, green, or even chocolate. The sandstone is usually cream and buff, but sometimes yellow and brown. Joints are widely spaced in the sandstone and less so in the shales.

Rock asphalt occurs locally in the lower five feet of the Tar Springs formation at Tar Springs, Cloverport, and Little Tar Springs.

A five inch seam of coal was noted near the top of the Tar Springs on a tributary of Indian Creek one and a half miles southwest of Jeffry cliff in Skillman Rectangle.

West of its area of outcrop, the Tar Springs offers possibilities as an oil and gas sand. Some wells and showings from "Stray" and "Jett" sands are evidently from this horizon.

The two sections below represent the maximum and the minimum development of the formation.

Section at Tar Springs, type locality.

- e. Menard limestone.
 - d. 10 feet, medium bedded, medium grained, light brown sandstone.
 - c. 55 feet, massive, medium grained, light brown sandstone.
 - b. 5 feet, rock asphalt, same sandstone as in interval above.
 - a. Glen Dean limestone and shale.
- Total thickness of Tar Springs, 70 feet.

Section at Falls of Rough.

- e. Menard limestone, yellow, much weathered.
 - d. 14 feet, arenaceous shale.
 - c. 11 feet, blue arenaceous shale.
 - b. 3 inches, greenish, flinty sandstone.
 - a. Glen Dean shale and limestone.
- Total thickness of Tar Springs at Falls of Rough, 25 feet and three inches.

Stratigraphic Relations. The unconformity at the base of the Tar Springs sandstone has been discussed, and there is no evidence of an erosional disconformity at its top, regardless of the fact that the change in character of materials is very abrupt and complete. There is no basal conglomerate, no undulating contact, and no beveling of strata. Usually a thin bed of shale is present at the contact, its nature indicating that in some localities it is all Menard and that in others it is partly Tar Springs and partly Menard. At Little Tar Springs, six inches of calcareous shale or marl occurs between the massive Tar Springs sandstone and the overlying thick bedded Menard limestone; and on a tributary of Indian Creek, one and one-half mile southwest of Jeffry Cliff, six inches of calcareous shale, one foot of arenaceous shale, five inches of coal, and more arenaceous shale lie beneath the Menard.

The evidence justifies the conclusion that the upper surface was flat at the close of Tar Springs sedimentation and that it was subjected neither to deposition nor to erosion while the Vienna and Waltersburg formations were being deposited farther west.

Correlation. A comparison of the sections studied by Weller, Sutton, Butts, and others in other parts of Kentucky and in Illinois, leaves no doubt that the sandstone they observed immediately above the Glen Dean limestone is identical

with the Tar Springs of the type locality. The writer has traced the outcrop of Tar Springs sandstone into the Leitchfield area where it becomes the basal member of the Leitchfield formation. The Vienna limestone and Waltersburg sandstone, present between Tar Springs and Menard farther west, have not been recognized here. Beds equivalent in age to the Vienna and Waltersburg may not have been deposited or, possibly, they may be represented in the lower portion of the Menard.

Paleontology. Fossils in the Tar Springs are rare, only Stigmaria and Lepidodendron having been observed. Butts¹⁷ however, reports Cardiopteris polymorpha from Tar Springs shale one mile east of Skillman.

Buffalo Wallow

Name. A thick series of upper Chester limestones, sandstones, and shales, which evidently include representatives of Menard limestone, Palestine sandstone, Clore limestone, Degonia sandstone and Kinkaïd limestone lies above the Tar Springs sandstone in this area. All the formations which have been described by Weller¹⁸ at this horizon in western Kentucky and southern Illinois occur, except the Vienna lime-

17. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917, p. 105.

18. Stuart Weller, Kentucky Geological Survey, Sixth Series, Volumes 4, 10, 26, et al.

stone and Waltersburg Sandstone, which have no representatives here. It would be difficult but possible to map and describe these beds as distinct units, but the writer has followed Butts¹⁹ and combined them under the general name of Buffalo Wallow. Butts named the formation from a cirque-like erosion feature in the characteristic shales in the upper part of the formation. The type locality is situated in a gap of the ridge two miles west of Cloverport and one mile south of little Tar Springs. The early settlers in this region assumed that this excavation had been made by the wallowing of buffaloes stopping here in their movements along the trail paralleling the Ohio river, hence the name.

Distribution. With the exception of the Pottsville, the area of outcrop of this formation is larger than that of any other formation. It is exposed continuously along both sides of the Rough River disturbance and is involved in the faulting. It crops out continuously from Rough River in the southern part of Fordsville Quadrangle to Skillman on Ohio River and is exposed in discontinuous areas to the northeastern margin of Cannelton Quadrangle. Its broadest exposures are between Glen Dean and Cloverport, where good development of the resistant underlying Tar Springs sandstone holds it up in flats and more gentle slopes than it can maintain else-

19. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917, p. 112.

where. West of Indian Creek Fault it shows in Shafer Hill, in a railroad cut in the bluff of Ohio River one mile southeast of Hawesville, and at a point one-half mile southeast of Indian Lake. Several inliers or windows of Buffalo Wallow occur west of the main north-south divide across the area and south of the Rough River diastrophic disturbance where elevations on the pre-Pottsville erosion surface and concave valley profiles coincide. In every instance the Kinkaïd limestone is found in these windows, indicating that they represent high places on the pre-Pottsville erosion surface or thick sections of Buffalo Wallow.

Width and continuity of outcrop are affected by the rapidly varying thickness of the Buffalo Wallow which is due in turn to the varying depth of post-Mississippian erosion into the Buffalo Wallow. One example of this is found by comparing the outcrop along Pond Run where the Buffalo Wallow is thin, with that of some other creek valleys. Another good example is seen in the discontinuous, patchy aspect of the outcrops in the upper drainage area of Adams Creek in the region of Fordsville.

Thickness. The thickness of the Buffalo Wallow formation ranges from about 30 to 200 feet.

Topography. In general, the area of outcrop of the Buffalo Wallow is rugged and the soil thin and poor. In a few places the sandstones form low bluffs or cliffs and occasional waterfalls on small streams. The Menard and Kin-

kaid form low bluffs in a few places. A number of sink holes, in various localities, rimmed by the Tradewater formation lead into solution channels in the underlying Kinkaid. At least one such sink contains a pond, at the hilltop one-half mile south of Cane Ford on Rough River.

The Palestine sandstone has its best development between Rockvale and Tar Fork, and the Degonia in the region of Hites Falls. In these localities they are terrace forming.

Lithologic Character. This formation is chiefly soft blue shale which turns green on exposure, but, as suggested above, nearly all outcrops of the full section reveal three calcareous and two sandy horizons. Probably the most striking feature of this formation is the erosion of the shale into broad gullies and cirque-like "Buffalo Wallows" with surfaces almost free from vegetation and covered with the minutely broken fragments of shale of a delicate green hue. Almost equally striking is the peculiar yellow or orange limestone locally found at all three limestone horizons and almost invariably associated with the Clore beds. However, much of the limestone is gray and usually dense. The sandstone horizons vary laterally from arenaceous shale to thick bedded, bluff forming sandstone. A disconformity, including a conglomerate was noted at the base of the Degonia sandstone in several localities and in places as widely separated as Buffalo Wallow and Tousey.

Usually a few inches of blue calcareous shale which belongs with the Menard at the Tar Springs-Menard contact is present but where the thickness of shale at the contact is greater than a few inches, most of it is non-calcareous and evidently belongs to the Tar Springs. The Menard limestone is usually medium to thick bedded, dense to crystalline, locally fossiliferous and crinoidal. It is tough and breaks with conchoidal fracture. The lowest bed is siliceous and yellow or yellowish, especially when weathered, but the other beds are gray or bluish gray. Locally the Menard contains layers of dark tabular, colitic chert, which breaks up into sub-rhombohedral fragments and weathers white, commonly advertising the presence of the Menard where the actual limestone cannot be seen. The thickness of the Menard limestone ranges from a minimum of one foot to a maximum of seven feet. Nowhere does it seem to be entirely absent. The section at Little Tar Springs exhibits the typical characteristics of the Menard. This is the best exposure along Highway 60.

Some of the shale lying above the Menard limestone evidently belongs with it, but it would be difficult to locate exactly where the Menard ends and the Palestine begins. The shale interval between Menard limestone and Palestine sandstone is about twenty-two feet and quite uniform in thickness everywhere. The division would have to be made on the basis of percentage of sand in the shale. This lower Buffalo Wallow shale is, like all the others, soft and blue when fresh,

and green when exposed. Its persistence, its thinness, its numerous outcrops, and its ease of recognition, even in well logs, makes the Menard a very satisfactory datum plane in the mapping of structure and a convenient marker for separating Tar Springs and Buffalo Wallow shales.

Palestine sandstone varies from a few feet of arenaceous shale to a well developed medium grained sandstone ledge ten or more feet thick with individual beds ranging up to eighteen inches in thickness. Only rarely is sandstone absent at this horizon. It is commonly beautifully ripple marked, hard, white when fresh, relatively highly fossiliferous, and breaks into long blocks like quarried stone. It is displayed to best advantage in a railroad cut and a little waterfall near a road crossing half way between Vanzant and Rockvale, and also one-fourth mile southeast of Black Lick Church and in the road near Dean School. In the latter locality some remarkably well preserved Stigmaria are embedded in the sandstone. Loose blocks and a ledge of the sandstone appear just above the Highway at Little Tar Springs. At this point many beautiful impressions of plant stems and foliage were collected. It is probable that this sandstone may yield petroleum as a "stray" sand where it lies far enough below the surface. Its position is shown in the section measured at Little Tar Springs, Page 87. It is five feet thick at the depot at Olaton. In certain localities Palestine may easily be mistaken for Tar Springs.

Above the more sandy portion of the Palestine horizon there is a gradual blending of the arenaceous shale into the soft blue-green shale which evidently belongs to the Clore limestone, the next higher member of the Buffalo Wallow. The thickness of the shale interval here is twenty-five or thirty feet. Fragments or ledges of the yellow lower beds of the Clore and usually portions of the upper, dense gray beds appear in all good exposures within the two quadrangles.

Because of the non-resistant character of the limestone and the slumping of it and the associated shale beds, it is difficult to determine the thickness of the Clore horizon. Beds of impure limestone intercalated with soft shale, the shale far in excess of limestone, have been observed to range through a thickness of from fifty to seventy feet. Probably all of this, including some of the underlying and overlying shale up to the disconformity at the base of the De-gonia, should be regarded as Clore. The usual sequence in the interval exhibiting limestone beds is a lower portion from fifteen to eighteen feet thick containing several beds of yellow, impure, argillaceous, calcite veined limestone three to eight inches thick, intercalated with about equal amounts of shale. Above this are one or two beds of gray, dense, tough, argillaceous limestone, each one to two feet thick. The latter beds are persistent and would make a good datum plane for the mapping of structure. Next above, is a thick shale interval and at the top another interval of yellow lime-

stone beds sparsely distributed through shale. In general, the Clore is rather unfossiliferous, but locally it is highly fossiliferous, certain thin beds of yellow limestone being crowded with Spirifer increbescens and Composita subquadrata. The abundance of large specimens of these two forms together with the position of this limestone in the section seem to justify correlating it with the Clore formation of western Kentucky and Southern Illinois, but, this correlation is only tentative, until detailed work has connected the upper Chester outcrops between this area and western Kentucky. Another thick shale interval occurs between the higher beds of Clore limestone and the sandstone horizon which is here correlated with the Degonia.

A peculiar limestone conglomerate with a calcareous shale or limestone matrix inclosing water-rounded pebbles of limestone, shale and shale concretions was observed at the base of the Degonia sandstone in several localities. At Buffalo Wallow this conglomerate is about three feet thick and is of like thickness in other localities. This conglomerate and erosional disconformity exposed at the base of a cliff of Degonia sandstone, one mile northwest of Hites Falls and elsewhere lead to the conclusion that there is at least a local disconformity and probably an extensive one at this horizon.

The Degonia sandstone is well developed in the upper drainage area of Beech Fork of Clover Creek, near Vanzant,

one mile northwest of Hites Falls where it forms a massive sandstone cliff twelve feet high, and on the west end of Powells Hill one mile east of Glen Dean where it is twenty feet thick, shaly and flaggy. It is rare that a careful search does not reveal sandstone at this horizon. The most common expression is a single bed of hard, medium grained sandstone, one to one and one-half feet in thickness, which becomes a dark reddish or rusty brown on exposure. At the type locality of the Buffalo Wallow the Degonia, as already stated, has about three feet of a peculiar conglomerate at its base. Above this is a coarse light brown calcareous sandstone minutely cross bedded in various directions as if it were deposited by shifting currents in a shallow sea. These beds form small terraces and flats in some localities. The maximum thickness of Degonia sandstone seems to be about twenty feet, but some of the overlying shale doubtless belongs with this member. At the outcrops one mile northwest of Hites Falls and one mile northwest of Dukes Store, numerous impressions of Stigmaria and Lepidodendron appear. Beyond this the Degonia is rather unfossiliferous.

A varying thickness of red, blue, and green shale occurs between the Degonia sandstone and the highest limestone in the Buffalo Wallow. In the type locality of the Buffalo Wallow, this shale lies directly upon the Degonia. Cone in cone structure occurs at this horizon in a "Buffalo Wallow", or glade, one mile northeast of Tousey. The cone in cone is

in hard layers two or three inches thick in the midst of soft shale. The bases of the layers are flat, but the upper surfaces are pitted in dentate fashion.

At the top of the Buffalo Wallow section in many localities there is a medium to thick bedded, dense to slightly crystalline, moderately fossiliferous, bluish gray limestone, in contact with the overlying Pottsville formation. In order to be consistent with the tentative correlation of the beds in the lower part of the section, this limestone is called, Kinkaid, the name given by Weller²⁰ to the top member of the upper Chester from Kinkaid Creek in Jackson County, Illinois. Except where affected by pre-Pottsville erosion, this is a thick formation in southern Illinois and western Kentucky. J. Marvin Weller²¹ seems not to have found its correlative in Edmonson County, Kentucky. Butts²² noted this limestone in two localities in the area now being considered, but did not name it.

The Kinkaid is exceedingly local in its distribution. Prior to the interruption of the post-Mississippian erosion cycle, it capped only the highest elevations in a topography which had a local relief of more than 150 feet in Carmelton

20. Stuart Weller, The Geology of Jackson County, Illinois, Illinois Geological Survey.

21. J. Marvin Weller, Geology of Edmonson County, Kentucky Geological Survey, Series VI, Vol. 28, 1927.

22. Charles Butts, Mississippian Series of Western Kentucky, Kentucky Geological Survey, 1917, p. 113.

and Fordsville Quadrangles. Between the tops of the highest elevations the Kinkaid had been entirely removed. With the Pottsville inundation and aggradation, the pre-Pottsville erosion forms were covered as they stood. The reexcavation of this buried topography by subsequent erosion has resulted in very peculiar and surprising conditions of outcrop of the Kinkaid. Its presence or absence cannot be predicted and its line of contact with the Pottsville runs at all angles from horizontal to vertical. The Kinkaid limestone comprises the highest beds of the Mississippian system. It crops out discontinuously in rather widely separated localities along the main or continuous Buffalo Wallow-Pottsville contact. It underlies a few of the Pottsville outliers, and appears beneath the conglomerate member of the Pottsville, one mile up the river from Hawesville.

The Buffalo Wallow mapped in windows west of the main north-south divide and south of the Rough River Fault zone is almost entirely Kinkaid. It is well exposed in the towns of Fordsville and Elmitch, just east of Narrows, one mile north of Davidson, at Easton, near Tar Fork post office, one-half mile north of Vanzant, at the Victoria oil field and Cannel Coal Mine, and one mile east of Patesville. In the vicinity of Buffalo Wallow it crops out one mile southwest of the type locality. It was not observed at any point northeast of Cloverport, although the thickness of the Buffalo Wallow indicates that it may be present in the hills north

of Goshagen and Bull Creeks.

The location and lack of continuity of the Buffalo Wallow outcrops in the region of Fordsville and Elmitch illustrates the effects of the pre-Pottsville and present erosion cycles upon the distribution of the outcrops. In view of the fact that pre-Pottsville erosion removed all the Kinkaïd from most of the area and some of it from all of the area, the present thickness of from 0-30 feet gives no clue to the original thickness of the formation. In western Kentucky and southern Illinois its thickness is as great as 180 feet.²³ It is probable that the Kinkaïd of the northeastern margin of the western Kentucky Coal Field originally had a like thickness.

The Kinkaïd and the Menard are quite similar. Much of the former is a medium to thick bedded, bluish gray, dense, locally fossiliferous limestone, which weathers to rounded gray surfaces. Locally there are beds which are moderately crystalline. The greatest observed thickness of this upper limestone member is twenty-seven feet. Usually a few feet of gray, blue, or varicolored shale, and locally, at least, one or more thin beds of yellow, impure, fossiliferous limestone underlie the upper limestone members.

Locally the Kinkaïd is highly fossiliferous and some fossils can be found on nearly all outcrops. Diaphragmus elegans and Composita trinuclea occur very commonly. At

23. Stuart Weller, Geology of Princeton Quadrangle, Kentucky Geological Survey, Series VI, Vol. 10, 1923, p. 87.

least for the region under consideration, a species of the bryozoan Tabulipora, most likely Tabulipora tuberculata, is highly characteristic. A short search will reveal specimens of this bryozoan on every outcrop of Kinkaïd and most exposures are covered with light gray concentrically banded spots where it has been sectioned by weathering. Although abundant in the Kinkaïd, it has not been observed at any other horizon.

The correlation of this limestone is regarded as tentative, but it is highly probable that it is a correlative of the Kinkaïd.

The following composite section made from exposures in the vicinity of the type locality exemplifies the general character of the Buffalo Wallow formation.

Pottsville Shales and Sandstones

Kinkaïd limestone	(Gray, rather dense, hard brown (on weathered surface, exfoliates rapidly.	8 feet.
	(Thick bedded, dark gray, fossiliferous, with the characteristic <u>Tabulipora</u> near the base.	8 feet
Shale	Bluish gray, soft	11 feet
Sandstone	Shelly gray	3 inches
Shale	Bluish-green to reddish	30 feet
Degonis Sandstone	(Coarse, light brown, calcareous (cross-bedded	3 feet
Limestone Conglomerate	with limestone and clay pebbles in calcareous matrix. Local disconformity	3 feet
Shale	Blue-green	30 feet

Clore Limestone	Dense, gray, nonfossiliferous, (Thin beds of yellow and gray im- pure, locally highly fossilifer- ous limestone intercalated with shale, certain shale beds are sandy. Limestone cut by many ir- regular, fine veins of calcite. (Far more shale than limestone.	2 feet 43 feet
Shale	(Blue-green, soft, somewhat arenaceous in lower part	30 feet

Part of Section below Measured at Little Tar Springs.

Palestine Sandstone	(Thin bedded, medium grained, light brown to greenish gray. Some beds are chert-like. Many plant fossils	2-2/3 ft.
Shale	Blue-green, soft	22 feet
Menard limestone	(A thick bed of bluish gray, crystalline. Few fossils except a branching bryozoan. Gray, less crystalline than beds below more easily ex- foliated, crinoidal, horn corals, Fenestella. (Crystalline, gray, frinoidal with many bases of <u>Aggassi-</u> <u>zocrinus</u> and other fragmentary fossils. (Yellowish or brownish, slightly crystalline limestone with fragmentary fossils. (Blue, calcareous shale or marl (Tar Springs sandstone and shale	2 1/4 feet 7 inches 1 foot 2 inches 6 inches 54 feet

Stratigraphic Relations. The seemingly conformable contact at the base of the Buffalo Wallow and the possibility of a disconformity within the formation have already been discussed. Likewise, the great unconformity between the Buffalo Wallow and the overlying Pennsylvanian strata has

been mentioned in connection with the Kinkaid limestone. The unconformity which separates the two Carboniferous systems is a highly conspicuous stratigraphic feature and represents not only a sedimentary hiatus, but also a period of extensive erosion during which the Buffalo Wallow formation was deeply trenched, producing a local relief of over 150 feet.

Paleontology. Fossils of greater or less abundance occur at five horizons in the Buffalo Wallow. The following lists show the fauna and flora usually present.

The Menard Limestone
Mostly from Little Tar Springs

Archimedes distans Ulrich
Archimedes sp.
Fenestella sp.
Septopora subquadrans Ulrich
Anisotrypa symetrica Ulrich
Polypora sp.
Spirifer increbescens Hall
Spiriferina spinosa N. and P.
Camarophoria explanata McChesney
Composita trinuclea Hall
Composita subquadrata Hall
Eumetria vera Hall
Productus ovatus Hall
Productus sp.
Diaphragmus elegans N. and P.
Orthotetes kaskaskiensis McChesney
Penetremites cf. serrata Hamback
Agassizocrinus conicus Owen & Shumard

Pelestine Sandstone
Mostly from Little Tar Springs

Stigmaria ficoides
Lepidodendron veltheimianum bark, leaves, bracts, and twigs
Sigillaria sp.
Rhodes sp. Delicate almost hairlike fronds.
Sphenopteris sp.

Clore Limestone

Chiefly from one and one-fourth miles south of Elmitch and from Pond Run, one mile northeast of Tristler School.

Orthotetes kaskaskiensis McChesney
Composita trinuclea Hall
Composita subquadrata Hall
Spirifer increbescens Hall
Spirifer leidy N. & P.
Eumetria vera Hall
Diaphragmus elegans N. & P.
Productus parvus M. & W.
Productus ovatus
Triplophyllum spinulosum Edwards & Hainie
Euomphalus planodorsatus M. & W.
Allorisma clavata McChesney
Septopora cf. *subquadrans*
Meekopora sp.
Archimedes sp.
Bellerophon chesterensis Weller
Long echinoid spines
Large fish tooth.

Kinkaid Limestone

Composita trinuclea Hall
Spirifer sp.
Triplophyllum spinulosum M.E. and H.
Spiriferina transversa McChesney
Spiriferina spinosa N. & P.
Productus ovatus Hall
Diaphragmus elegans N. & P.
Orthotetes kaskaskiensis McChesney
Girtyella indianensis Girty
Spiriferina subspinosa Weller
Tabulipora c.f. *tuberculata* Prout
Bellerophon sp.
Lingula sp.

Correlation. The fossils listed above evidently represent the fauna of the Menard, Clore, and Kinkaid formations and indicate strongly the equivalence of the Buffalo Wallow to those formations and to the Palestine and Degonia

sandstones included between them.

Pennsylvanian System

Pottsville Series

Introductory Statement:- Throughout most of the Mississippi and Ohio Valleys the strata of Mississippian and Pennsylvanian age are separated by an important erosional unconformity. In Fordsville and Cannelton Quadrangles, the local relief of the Mississippian surface exceeds 150 feet and the Pennsylvanian beds rest, at different localities, upon different members of the Buffalo Wallow formation. Sand Knob and the high ridge just beyond the eastern margin of the Fordsville quadrangle on either side of the valley of Rouch River represent the filling of a deep channel by Pottsville sandstone. Here the Buffalo Wallow may have been eroded entirely through, and the Pottsville sandstone deposited upon the Tar Springs or even upon the Glen Dean formation but, within the two quadrangles, the deepest erosion failed to cut through the Buffalo Wallow and left a minimum thickness of about thirty feet of this formation.

During the deposition of Pennsylvanian sediments on the pre-Pottsville surface some of the tops of the ridges, flats and hills remained for considerable time as islands and doubtless furnished some of the material which filled the surrounding valleys. The Buffalo Wallow shales in this manner, may have been the source of some of the numerous clay

galls which occur in the sandstone of the Pottsville.

On the Cloverport-Dukes Store Road, two miles southwest of Cloverport, the relations mentioned above are clearly shown. On the northeast end of the ridge the Buffalo Wallow formation is only 129 feet thick with its top at 604 feet elevation. A thin, local seam of coal occurs at 625 feet A.T. and one-fourth mile farther west, in the down dip direction, another seam of coal, also thin and local is present at 650 feet. One-half mile still farther west and still down dip the Kinkaïd limestone appears at 660 feet A.T., higher than either of the coal seams. At the latter point, the Buffalo Wallow formation is about 200 feet thick. This point or hill on the eroded Mississippian surface stood as an island in the surrounding swamps of two coal forming cycles.

All the Pennsylvanian strata in the two quadrangles are of Pottsville age and evidently include the Caseyville and Tradewater formations of Owen and Glenn²⁴. As a result of the study of the fossils associated with the Lead Creek limestone in Indiana, David White thought the upper boundary of the Pottsville should be placed at about the top of this limestone, which lies, according to Crider²⁵, about 255 feet above the Pottsville conglomerate. This limestone was not observed and evidently has been eroded from the tops of the

24. L. C. Glenn, Coals of the Tradewater River Region, Kentucky Geological Survey, Bul. No. 17.

25. A. F. Crider, Economic Geology of Tell City and Owensboro Quadrangles, Kentucky Geological Survey, Series IV, Vol. 1, Part 1.

highest hills in the western part of the area. It would be very difficult to make a logical subdivision of the Pottsville in this area and any division of strata would necessarily have to be arbitrary. A division plane could be placed at the top of the massive conglomerate and sandstone at Hawesville, forty feet below the Hawesville coal, but the character of the beds below this level changes notably in every direction within a few miles and the reason for such a separation disappears. Again, the dividing surface could be placed at the top of the Nawesville coal where marine or brackish water fossils occur in the shale, but the argument for that would not be very convincing. So all efforts to find a logical basis for the subdivision of the Pottsville in this area were abandoned. Since there was a desire on the part of the Kentucky Geological Survey to indicate on the map the area of outcrop of the conglomerate and massive sandstone which are so conspicuous along Highway 60 from Hawesville to Shafer Hill, a division for mapping purposes was made on the basis of lithology and for the sake of convenience one mapping unit has been called Caseyville and the other Tradewater. In the present work only the local conglomeratic phase of the formation and the massive sandstone, also local, lying just above it, have been mapped as Caseyville conglomerate. All other Pottsville sediments at whatever horizon and regardless of time relations with the so-called Caseyville were mapped as belonging to the Tradewater formation. With this explanation

of the map the names Caseyville and Tradewater will not be used again in this report.

Distribution. The distribution of the conglomerate is peculiar. It might be expected that all the lower portions of the pre-Pottsville topography would be filled with conglomerate but such is not the case. The conglomerate occurs only in a comparatively small area in the west central part of the Cannelton quadrangle along the Ohio river. It is doubtless a channel filling, but the channel that was filled with coarse sediments was little if any deeper than many others in the area whose bottoms received only shales and shaly sandstone. The conglomeratic sediments were probably deposited along the immediate course of a large, rapidly aggrading river flowing through the area from the east. The rapid filling of the main channel or valley left the tributary valleys ponded into long irregular lakes of quiet water much as they were during the Pleistocene ponding. In these quiet waters, locally derived silts, sands, and vegetable material, as well as silts and sands of more distant origin gradually accumulated to the level of the top of the conglomerate in the main valley. This is analogous to the deposition of Pleistocene materials along the present Ohio River except that during the Pleistocene, floating ice dropped coarse materials among the finer sediments in the ponded valleys.

The conglomerate crops out continuously in cliffs and steep slopes from Indian Creek Fault to Hawesville. The upper part of it is exposed along most of the upper course of Lead Creek. Along the eastern or upthrow side of Indian Creek Fault south of Indian Creek, a few of the points or ends of ridges are tipped with high cliffs of conglomerate which ridgeward abut against shales and coals lying on the downthrow side of the fault. Shafer Hill is a hinge-like block of Pottsville conglomerate tilted steeply to the west with faults on two and possibly three or four sides. Jeffry Cliff displays the maximum thickness and best development of the conglomerate. The top of this hill is about a mile long and contains several hundred acres entirely surrounded by vertical and overhanging conglomeratic sandstone cliffs, in some places 140 feet high. The conglomerate changes very abruptly to shales and shaly sandstones. Sandstones which may be the time equivalent of the conglomerate occur locally at this horizon in other parts of the area, but in no other locality are they conglomeratic.

The Pottsville series cover approximately one-half of the area of Fordsville Quadrangle, with numerous outliers beyond the continuous border. In the western tier of rectangles the Pottsville is unbroken except for a few isolated outcrops of Buffalo Wallow and lower formations brought up along the Rough River zone of disturbance. Less than one-fourth of the area of the Kentucky portion of the Cannelton

quadrangle is covered by Pottsville.

Thickness. The maximum thickness of the Pottsville within the two quadrangles is approximately 300 feet. The region of greatest thickness is around the headwaters of the west fork of Adams Creek. The thickness varies with the topography at the top and the erosional unconformity at the base.

Topography. In general, the surface of the Pottsville area is rugged. The alternating sandstones and shale produce steep slopes interrupted by gentle terraces and culminating in flat-topped hills and ridges. Locally, thick, massive sandstones in the lower part of the section stand in vertical cliffs or produce steep slopes, but these are relatively rare. The conglomerate, confined to the Skillman rectangle of Cannelton Quadrangle, produces, as stated above, the most rugged and imposing topography in the entire area. Contrasted with this are many broad, gently rolling uplands or flats surfaced by resistant beds of Pottsville sandstone. Along the eastern margin of the area of its exposure the Pottsville furnishes a protecting cap for the less resistant Buffalo Wallow, a condition which produces very steep slopes.

Lithologic Character. The lowermost member of the Pottsville, in the restricted area exhibiting conglomerate, is very similar to the Pottsville conglomerate found widely

distributed in the eastern part of the Mississippi Valley. It reaches its best development in Jeffry Cliff, where it rests directly upon the middle portion of the Buffalo Wallow formation. Here it is a river valley filling with many cross beds which indicate the southwestward direction of the river's flow. White quartz pebbles which are fewer and smaller than is usual in Pottsville conglomerate, range in size up to half an inch, and are arranged in thin stringers and occasional beds in a moderately coarse grained sandstone matrix cemented with iron.

Between the river and Highway 60 just above Hawesville, the conglomeratic phase is thinner, the middle portion of the section being sandy shale and shaly sandstone and the upper portion thick bedded to massive sandstone. The following section is between Highway 60 and the railroad one mile southeast of Hawesville.

Mapped as Tradewater in Skillman Rectangle in Cannelton Quadrangle:

14. Soil at top of ridge	
13. Buff colored, medium grained, medium bedded sandstone	45 feet
12. Dark shale and thin bedded sandstone	25 feet
11. Thin, local coal seam	1 foot
10. Black, carbonaceous shale	12 feet
9. Medium grained, thick bedded sandstone	3 feet
8. Thin bedded sandstone and shale	15 feet
7. Hawesville coal	3 feet
6. Shale and thin bedded sandstone	40 feet

Mapped as Caseyville in Skillman Rectangle, Cannelton Quadrangle.

5. Massive, bluff forming, cross bedded sandstone	24 feet
4. Sandy shale and thin bedded sandstone	28 feet
3. Conglomerate and sandstone, very few pebbles	35 feet

Buffalo Wallow

2. Dense, gray, fossiliferous, Kinkaidd limestone.	
Beds from 2 to 6 inches thick.	11 feet
1. Blue, Buffalo Wallow shale	8 feet

Total thickness of Section 250 feet

The above section is applicable to the Indian Creek-Lead Creek locality only, the Hawesville coal being the only recognizable horizon extending beyond this locality. Elsewhere there is far more shale and argillaceous and thin bedded sandstone. In most places a considerable thickness of the basal portion of the formation is composed of carbonaceous shale as at Patesville. Locally, however, there are thick bedded to massive sandstones in the basal portion. Such a sandstone on the east side of the hill northeast of the point where Blackbord Creek leaves the Cannelton Quadrangle is forty feet thick. In various localities, such as Balltown, Askin, Barton School, Tristler School, and the southwestern corner of Cannelton Quadrangle the surface of the hilltops and flats are underlain by a clean, coarse, light brown to pinkish red, slightly indurated sandstone. Such sandstone is responsible for much of the flat or rolling upland.

The Hawesville coal is persistent over most of the western portion of the area, but it is so high in the sec-

tion that it is found only in the higher hills and ridges except in the region bounded by Indian Creek fault, Indian Creek, Ohio river and the western margin of the quadrangle. Nearly all the mines (past and present) in the region of Hawesville and those in the drainage basins of Lead, Caney, and Blackford Creeks are in this seam. East of Indian Creek Fault, near the head of Caney Creek, it is being mined in a hilltop at 640 to 650 feet elevation.

Between Blackford Creek and Fordsville the Hawesville coal is thin and shaly. The mines in the high hills to the southeast and the southwest of Fordsville and those to the northeast of Narrows are at about the Hawesville horizon and evidently should be referred to it. A coal twenty inches thick has been mined for many years for local use from about the Hawesville horizon one and one-half miles southeast of Falls of Rough. The same coal occurs also just southeast of the Locust Hill fault. The Hawesville was used as a datum plane in mapping the structure of Hancock County. Near Hawesville, there is another thin seam of coal, associated with a considerable thickness of carbonaceous shale, about thirty feet above the Hawesville coal. This is probably the coal that occurs high in the hills in a few other localities farther south. Nowhere does it seem to be of workable thickness.

Outcrops of thin, local coal beds occur at several horizons below the Hawesville, but only one of these at one

place, the Breckinridge Cannel Coal at the Old Victoria mines, is worthy of mention. This famous deposit of cannal coal is located at Victoria on the Hancock-Breckinridge county line at the southern edge of Cannelton Quadrangle, about seven miles southwest of Cloverport. Stratigraphically, it lies about one hundred feet below the Hawesville coal horizon and about twenty-five feet about the Kinkaidd limestone, with a coarse, micaceous, soft sandstone and a thin bed of fire clay between the coal and the limestone. In the Ohio river bluff, one mile above Hawesville the Kinkaidd limestone is 127 feet below the Hawesville coal. At Victoria the Breckinridge coal is reported to have been from 22 to 36 inches with an average of 30 inches in the old mines. It thins rapidly in every direction. Breckinridge Cannel Coal is dull black, with a satiny lustre on the cross fracture. It is very tough, breaks with great difficulty, cleaves into thin layers and does not soil the fingers. It has fine particles of pyrite and impressions of *Lepidodendron*, but no fibrous coal between the layers and burns with a yellow, smoky flame. It compares very favorably in quality with the famous Boghead Coal of Scotland and is remarkable for the large proportion of volatile combustible matters which it yields. The roof is of carbonaceous shale, over which lies a brown sandstone.

The outcrop and mines are about 120 feet above the nearby Keg Branch Valley floor and about 100 feet below the

top of the ridge. Breckinridge Cannel coal of workable thickness is exceedingly restricted in area. The supply was practically exhausted before the Civil War, and in the years immediately following 1875 the mining of all coal of workable thickness was completed. A thin ordinary bituminous coal, often associated with considerable carbonaceous shale, is widely distributed over the two quadrangles at about the horizon of the Breckinridge, cropping out along Panther and Adams Creeks and in many places along the Pottsville periphery. It has been prospected or mined a little in various places, but has always proved to be too thin, or too shaly to justify development except for local domestic use. This seam is probably a continuation of the Breckinridge coal beyond its area of cannelization. The question naturally arises as to the nature of the conditions and materials which resulted in such a highly localized deposit as the Breckinridge Cannel Coal. It is generally accepted among geologists that cannel coal is formed chiefly from the spore cases, rich in resin or oil, of the great lycopod trees of Coal Measure time. These light, high floating, spore cases could have been driven relatively long distances by the wind over the surface of open water and accumulated in some shallow bog or swamp of quiet water near the leeward shore.

In early Pottsville time a shallow lake, due to the choking of the main stream by sediment, may have existed in the region of southern Hancock and northeastern Ohio counties

with its eastern shore and a forest protected shallow bay or swamp near Victoria. An extensive forest of lycopods whose spores fell or blew onto the water in countless numbers over a wide area grew around this lake. The wind presumably blowing then, as now, prevailing from the west in dry weather, drove the myriads of spores from the broad surface of the lake into a comparatively restricted and protected area at the eastern end, where they, in time became water logged and settled to the bottom. Occasional stems of the lycopods drifted or fell into the deposit of spore cases. Thus a comparatively thick bed of material composed chiefly of spore cases, which form a relatively insignificant proportion of the total amount of vegetable material produced by the individual tree was deposited, while a thinner deposit later to form ordinary bituminous coal and carbonaceous shale was being laid down over the bottom of the remainder of the lake and its swampy margins.

Stratigraphic Relations. The unconformity at the base of the Pottsville has already been discussed. Local disconformities exist within the Pottsville strata and, the unconformity at its contact with the overlying Tertiary and Quaternary sediments represents all the time which elapsed between the close of Pennsylvanian deposition and the beginning of deposition of these comparatively recent beds.

Paleontology. The Pottsville, as a whole, is not very

fossiliferous. Scattered Lepidodendron, Sigillaria, and Stigmaria occur in the sandstone and these, plus Calamites are nearly always found in coal beds and the over lying shale. The dark gray shale above the Hawesville coal contains many Lingula umbonata, Lepidostrobus and broken remains of Pecopteris, Sphenopteris, and Alethopteris.

The Cretaceous System

During the long time which has elapsed between the Pennsylvanian period and the present, the part of Kentucky now under consideration evidently has been dry land continuously, and for much of that time it has been subject to sub-aerial erosion. If deposits of middle and late Pennsylvanian, Permian, Triassic, and Jurassic age were laid down in this area they were entirely removed by subsequent erosion which also destroyed all vestiges of any peneplain surfaces or other topographic features which may have been developed during these periods.

Likewise deposits and land surfaces which may be assigned to the Cretaceous period are extremely vestigial. However, it is the writer's opinion that the few widely scattered high hills and ridges, those whose tops reach the elevation of 800 feet are the last remnants of a Cretaceous peneplain. These highest elevations are all of very small area, but usually flat topped and 800 to 830 feet, A.T. This theory is strengthened by the occurrence either on or

near these tops of profoundly waterworn quartzite and vein quartz boulders of a type which the writer has learned to associate with the Cretaceous surface in other parts of the State. The quartzite boulders range in color from light to dark brown and in texture from dense to conglomeratic, and rarely one is found which contains worm burrows. The vein quartz boulders are of white or milky quartz. Usually the surfaces of these boulders have patches of limonite adhering to them, indicating that they may have been a part of an indurated bed at no very distant geological time, but no undisturbed beds containing these boulders have been found in Kentucky east of Trigg and Lyon counties.

The quartzite and quartz boulders may have come from the Appalachians and have been distributed over the Cretaceous surface by westward flowing rivers either through direct wash or by rafting in river ice. In view of the size of some of the boulders (forty-five pounds) the latter method would seem the more plausible on a nearly plane surface and in rivers of low gradient. These boulders seem never to have been found in the undisturbed beds of deposits of known Tertiary age. This is strange, since they must have been present on the higher surfaces while the Tertiary gravels were being deposited at lower levels. Perhaps, the quartzite boulders were no more numerous in Tertiary time than they are at present.

Associated with the quartzite boulders on the flat

topped hill north of Goshagen Creek in Cloverport Rectangle are chert gravels of the Tertiary type at 780 feet A.T., but whether these belong to the latest Cretaceous or the earliest Tertiary deposition cannot be determined.

The Tertiary System

Lafayette Gravel

Name. Surficial deposits of gravels and sands which are largely unconsolidated have been observed at three distinct levels within the Fordsville and Cannelton quadrangles. At two levels they cap hills near the Ohio river and at the other they occupy the bottoms of old, broad, shallow valleys along Ohio and Rough Rivers. These deposits doubtless represent the widely distributed and little understood formation to which the name "Lafayette Gravel" has been applied, although it is generally believed at the present time that gravels of different ages and origins have been included under this name.

Distribution. These deposits of gravel and sand are all located near the Ohio or Rough River and occur at three or four distinct levels in patches of limited area. As stated above, the west end of the high hill north of Goshagen Creek in Cannelton Quadrangle has a sprinkling of waterworn gravels up to the 800 foot level and in the road near the farm house on the hill at about 780 feet A.T. there is a red clay containing chert pebbles, but whether this is

a regular deposit, or merely residual material could not be determined. Iron ore and red clay near the middle of the ridge at 800 feet may be of the same age.

Scattered chert gravels which are probably residual from former beds occur on the hilltops in the northeastern corner of Cannelton Quadrangle. The highest of these hills is 686 feet A.T. The next highest level is near the Ohio river two miles northeast of Stephensport on the margin of Cannelton Quadrangle, where the base of the deposit rests on lower Buffalo Wallow shale at 700 feet. Next in descending order are the deposits at the tops of the hills which stand at 600 feet on the western margin of Cannelton Quadrangle between Lead Creek and Duncan School. The latter deposit overlies Pottsville shale and sandstone above the Hawesville coal. It is possible that the Stephensport and Lead Creek deposits are contemporaneous in deposition and identical in origin. They lie fifteen miles apart along the course of the westward flowing river which deposited them. The deposit which is now the lower, being down stream from the other, was originally deposited at a somewhat lower level and subsequent warping of the earth's surface could easily have accounted for the remainder of the difference in present elevation.

The lowest level at which similar deposits occur is quite uniformly at or near 500 feet A.T. in both the Ohio and Rough river valleys, suggesting that little or no earth move-

ment has taken place since their deposition. The thickest, most conspicuous, but not at present the most extensive deposit is located at the tops of some low hills which rise above the alluvial plain of the Ohio river immediately to the southeast of Skillman. The base of this deposit rests upon lower Buffalo Wallow shale at 500 feet A.T., which is 90 feet above the surface of the surrounding alluvial plain and 150 feet above the present surface of the river at low water. It is fluvial and was deposited on the valley bottom of the late Tertiary predecessor of the Ohio river.

A deposit of similar materials of interesting areal distribution occurs in the western part of Skillman Rectangle, on a terrace on both sides of Lead and Caney Creeks and in the saddle or divide between the head waters of these streams. The base of these sediments likewise is at 500 feet elevation. Clearly, these deposits were made in a broad, shallow valley of a stream which flowed along the present courses and across the divide between the heads of Lead and Caney Creeks. Probably this was a portion of a meander of the stream which made the deposits near Skillman, and which at that time flowed up what is now Lead Creek valley and down the present course of Caney and Blackford Creeks. All the other deposits of Tertiary age are in the valley of Rough River and rest at approximately 500 feet A.T. The easternmost and most extensive of these deposits are in the vicinity of Falls of Rough, where the sands and gravels rest upon Glen Dean limestone and Tar Springs sandstone. There is one small deposit

near Hites Falls and several others in the region of Davidson and Narrows.

A small deposit of gravels one and one-half miles south of the present course of Rough River occurs on the road about three-fourths of a mile southeast of New Baymos School and one-fourth mile west of Cane Run. This locality must have been on a meander of Rough River in late Tertiary time. The deposits along Rough River Valley are only 20 to 40 feet above the alluvial plain and 60 to 80 feet above the river at low water.

Lithologic Character. The gravels at the three higher levels are composed largely of smoothly rounded chert pebbles varying in size up to a diameter of three inches. A few small water worn quartz pebbles from the Pottsville conglomerate are intermixed with the chert gravels but neither igneous nor metamorphic pebbles occur. The cherts in the deposits all or nearly all come from the formations of the Mississippian System and silicified fossils of Mississippian age occur frequently among the gravels. Most of the gravel is unconsolidated, but in places, especially near the base of the deposits, it has been cemented into thin crusts of rough iron conglomerate. Orange colored sand and red clay fill the interstices in some parts of the gravel beds. The thickness of the high level deposits could not be determined exactly, but it is not more than 12 to 15 feet.

The deposits which occur around the 500 foot level

near the Ohio river differ markedly from the higher level gravels described above in that they contain a much greater proportion of sand, clay, and sandstone pebbles and boulders. The deposit southeast of Skillman on the land of A. B. Sterrett was used in road beds first by the Henderson and Louisville Railroad and later by the Kentucky State Highway Department. Another pit was opened on this formation on the land of M. H. Minnett, one and one-half miles southeast of Hawesville. A description of the deposits in these pits illustrates well the character of the deposits in general.

In the Sterrett pit the vast majority of the gravels are of Mississippian cherts, many of them Mississippian goodes, concretions, and silicified crinoid stems and corals. Small Pottsville conglomerate quartz pebbles are sparsely scattered through the mixture which contains a few sandstone pebbles, usually larger and more rounded than the others, but no igneous or metamorphic pebbles. One large, well rounded, quartzite pebble of the kind which occurs on the Cretaceous surface was observed lying loose, but whether it came from this deposit is not known. Pieces of thoroughly rotted coal occur sparsely among the other materials. The gravels are in a reddish brown sand-clay matrix. Most of the sand is quartz, but a considerable sprinkling of mica grains also is present. The gravels are waterworn and sub-angular and range in size up to two and one-half inches with an average of about three-fourths of an inch. The upper

two and one-half feet of the deposit is composed of red clay with a little sand and a few sub-angular gravels. Most of the material is unconsolidated or only loosely consolidated, but a few thin beds are firmly cemented into rough feruginous conglomerate. The whole deposit is stained, yellow, brown, and even black, by iron. The deposit rests upon lower Buffalo Wal low shale about forty feet above the Menard limestone.

Section of Tertiary deposit in gravel pit on the property of A. B. Sterrett near Skillman:

Loess and soil	9 feet
Red clay with a few sub-angular gravels and some sand	2½ feet
Gravels, sub-angular, waterworn, mostly chert, but some quartz and sandstone, sand and clay matrix. Sand mainly quartz but some mica. Mostly unconsolidated but certain thin beds firmly cemented by iron into conglomerate.	20 feet
Total thickness of Tertiary deposit about	25 feet

The gravel from the Minnett pit one and one-half miles southeast of Hawesville was used extensively by the Kentucky State Highway Department in building Highway 60. The materials of this deposit are similar to those of the Sterrett pit except that the deposit is thinner and the proportions of gravels and sand very more rapidly both vertically and laterally. The sand is reddish orange, sometimes pinkish, mainly quartz, but with minor and varying proportions of mica. A little clay is mixed with the sand.

The gravels are almost wholly chert and the usual range in size is up to two inches with an average of three-fourths of an inch, but a few chert gravels are as much as four inches and one chert boulder of ten inches in diameter was observed. Silicified Mississippian fossils such as Lithostrotion canadense, Lithostrotion proliferum, horn corals, crinoid stems, and pieces of brachiopods are plentiful. Thin layers are consolidated into ferruginous sandstone and conglomerate. Near the middle and base of the deposit large, slightly waterworn sandstone boulders occur.

Some of the sandstone boulders seem to have had bands of ferruginous sandstone through them when they were deposited in this formation. Later these iron bands grew beyond the surfaces of the boulders into and including the surrounding sand and gravels producing fringes of iron conglomerate around and intimately attached to the boulders. This is an interesting case of the regrowth or secondary enlargement of rocks. The Minnett deposit is mantled by about ten feet of loess and soil and underlain by Pottsville. Other deposits at the 500 foot level along Lead and Caney Creeks are quite similar to those described above.

The Tertiary deposits in the valley of Rough River differ from those in the Ohio river valley in several particulars. The material is predominantly yellowish brown or orange colored sand, containing a minor proportion of clay. Most of the gravels are of sandstone, but some are of chert

and all are angular and show little erosion resulting from stream transportation. There are a few silicified fossils from the Mississippian. Mostly the materials are unindurated, but here, as in Tertiary deposits elsewhere, there are some firmly cemented crusts of rough ferruginous conglomerate and sandstone.

Origin. The character, disposition, and location of the deposits leave no doubt of the fluvial deposition of the sediments at the lowest or 500 foot level. Those along the Ohio were deposited on the bottom of the broad shallow valley of a westward flowing stream, which followed approximately the course of the present Ohio.

The materials deposited along the Ohio valley at the lowest level are nearly all of Mississippian and Pennsylvanian origin. The total absence of igneous and metamorphic rocks in the deposits proves definitely that this predecessor of the Ohio river had no tributary which penetrated the Appalachians far enough to reach outcrops of igneous and metamorphic rocks and that no glacier-bearing materials from the Canadian Shield, had yet entered its drainage basin. The river, which all evidence seems to indicate was smaller than the present Ohio, was flowing then at base level. Later uplift and increase of volume made possible the excavation to and below the present bottom of the Ohio River.

The case of the deposits along the Rough River is

equally clear and quite similar, except that the materials were of even more local origin because of the much smaller drainage basin of the river. The Tertiary predecessor of the Rough must have been a tributary of the Tertiary predecessor of the Ohio.

The case of the gravels at higher levels is not so clear, but it is illogical to invoke inundation for the solution of the problem when fluvial action offers a far more simple solution. No feature of the deposits is opposed to the idea of fluvial deposition. Likewise there is nothing which points definitely toward any other agent. The deposits are all near the present Ohio river, the most distant one observed in the area being only three miles from it. Thus these sediments, too, were deposited in a broad, shallow valley.

The problem raised by the occurrence of the gravels at different levels, ranging from 600 feet to 800 feet A.T. finds an easy solution in the theory that the deposits are in terraces or meanders abandoned by the river as it cut down toward a base level which may have been at about what is now the 600 foot level. The gravels have protected the areas, covered by them from erosion so that they stand among the highest features in the topography of today. However, the idea of successive uplifts followed by down cutting to base and deposition will explain the occurrences. All the higher level sediments definitely referred to the Tertiary are like-

wise of Mississippian and Pennsylvanian origin. There is no trace of material from distant regions. The probability of the scattered gravels and boulders of the highest or 800 foot level being of Cretaceous age and belonging to the Cretaceous erosion surface has been discussed. Certainly an element not found at the lower levels is present here. The quartzite and vein quartz pebbles and boulders traveled far and indicate that rivers whose headwaters penetrated far into the Appalachians were flowing across nearly the full length of Kentucky, a condition which did not exist during the deposition of the later or Tertiary sediments.

Age. The probable late Cretaceous age of the highest scattered chert, quartzite and quartz pebbles has been discussed. The age of the intermediate gravel deposits is doubtless the same as that of other widely distributed hilltop gravels which are present in the Ohio and Mississippi valleys. Although there may be some difference in the time of accumulation from place to place, the age of most of the gravel deposits doubtless falls within Tertiary time. Likewise the deposits at the lowest level must be put in the Tertiary.

To what part of the Tertiary should each deposit be assigned? Enough time must be allowed between the deposition of the sediments at the lowest level and the advent of Pleistocene glaciation for the Ohio or its forerunner to cut a broad valley in Paleozoic rocks, more than 160 feet deep,

and for the smaller, weaker Rough River to cut a valley more than 60 feet deep. However, most of this erosion was accomplished during the early part of the Quaternary and the deposition of glacio-fluvial material in the valleys occurred in the latest stages of the Pleistocene. Yet, at best, the latest Tertiary deposits must be placed in the late Pliocene, and, since one hundred to two hundred feet of erosion had to be accomplished between the time of the intermediate deposits and the lowest deposits by a river which, most of the time, could not have been working very far above base level, it seems reasonable to assign the intermediate deposits to the middle Tertiary or, at least, to the Miocene.

The Quaternary System

Pleistocene or Glacial Epoch

Glacio-Fluvial Valley Deposits. Fordsville and Cannelton Quadrangles lie directly south of the middle of the unglaciated portion of southern Indiana and the nearest approach of the glacial front in the Illinoian invasion was many miles away, up the Ohio river beyond Louisville, and the nearest approach in the Wisconsin stage was considerably more distant. Yet, the effects of the glacio-fluvial activity of the Glacial Epoch beyond the ice border are seen in the form of valley fillings along every stream within the area.

Distribution. Pleistocene gravels, sands, and silts fill the Ohio Valley to the level of 430 feet A.T. except

where post-Pleistocene erosion has cut below this level. The greater portion of the area of these deposits along the Kentucky side of the Ohio in Cannelton Quadrangle is found in three large flats or plains, each several square miles in area. One of these plains lies in the northeastern corner of the quadrangle, and the other two on either side of the neck of the great southward bend of the Ohio. The latter two are each more than two miles broad and three and one-half miles long. The western edge of the quadrangle includes the eastern part of Hawesville, the county seat of Hancock county, which is located on the western end of another large alluvial plain which lies mainly in Tell City Quadrangle. Cloverport and Stephensport stand on two smaller Pleistocene plains. All the towns near the Ohio river are located on these plains, as are also the railway and a part of the highway. This filling, whose top is probably of alluvium of more recent date than the Pleistocene, extends up all the tributaries of the Ohio for many miles or until the altitude of 440 feet is reached near the head of Clover Creek; 500 feet near the head of Blackford Creek; 500 feet on Panther Creek; 450 to 460 feet along Rough River and up to 480 feet in some of the longer tributaries of the Rough. The altitude of the filling at the head of a stream depends upon its distance from the Ohio river or rather on the length of the stream.

Topography. Post-Pleistocene erosion has changed the surface of the Quaternary deposits in many places. The trib-

utary streams have cut deep, steep sided trenches into them; meanders of the river have under cut them, producing steep banks, and sheet wash has probably modified the surface to some extent everywhere. Yet even in the middle of the broad plains which are essentially unchanged by erosion, the surface is far from flat. It may be best described by the term gently rolling, because there are long shallow swales and swells or flutings parallel with the course of the river which may be the result of differences in velocity of currents in different parts of the glacial flood.

In some places the natural levee of the Pleistocene flood plain is easily recognized. A good example of this may be observed along the road and railroad for a distance of three miles south of Addison. The road for most of this distance is situated immediately west of the crest of the levee which rises ten to twenty feet above the road. The farmhouses on the east side of the road are on the crest of the natural levee. The levee has a longer, more gentle outside slope and a shorter, steeper riverward slope.

Lithologic Characters. The gravels consist of all the igneous, metamorphic, and sedimentary erratics which are usually associated with the glacial drift as well as those of more local sedimentary origin. They are well rounded and assorted by fluvial action and any glacial striae or faceted surfaces which they may have possessed were entirely

removed while they were in transit from the ice front.

Light brown sand and blue or gray silt are interbedded with the gravels. The proportion of gravel and sand grows less toward the margins of the Ohio valley and up the tributary streams. Coarse pebbles which were doubtless dropped from floating ice, occur scattered through the silts and sands. The beds of different materials thicken and thin, narrow and broaden, or disappear very rapidly. Lenticular bedding is common.

In general, the materials in the valley fillings grow progressively finer for a few miles up the tributary valleys until they are composed almost entirely of silt. The otherwise fine material of the filling in the tributary valleys often contains smooth, waterworn erratic pebbles and boulders mixed with, or lying on the silts. Pebbles and boulders up to ten inches in diameter occur in and on the alluvial plains along Sinking, Clover, and Indian Creeks. On Clover Creek they occur in surprisingly large numbers as far upstream as the crossing of the Hardinsburg-Balltown road, nine miles, in a direct line from Ohio River.

Erratic pebbles and boulders have not been observed in the upper valley of Blackford Creek or in the portions of Rough River and its tributaries which lie in the Fordsville quadrangle, evidently because they were too far from the Ohio river for floating ice to reach them. The filling of the valleys of Blackford Creek, Rough River, and its tributaries is mainly of silt, local sands, and gravels. The Pleisto-

cene materials, as far as they have been observed, are wholly unconsolidated. Yet it is probable that thin layers at the bottom of the deposit are loosely cemented.

A water well drilled recently at Cloverport on the flood plain at a considerable distance from the river front showed the following section:

Section in water well at Cloverport.

Soil, clay and sand	38 feet
River gravel and sand	36 feet
Clay with slabs of limestone	2 feet
Total depth, 76 feet.	

Thickness. Few direct measurements of the thickness of Pleistocene deposits can be made. The water well at Cloverport shows a thickness of 76 feet. Trenching near the mouth of Bull Creek exposes a thickness of more than 80 feet. Doubtless the maximum thickness is more than 100 feet. On Tar Fork of Clover Creek, three miles south of Ohio River, the valley filling is at least fifty feet thick. There was little opportunity to measure the alluvium along the valleys of Rough River and its tributaries, but a thickness of 40 to 50 feet is probably about the maximum with an average of considerably less.

Origin. During the Illinoian and Wisconsin glaciations tremendous floods of glacial-born water carrying enormous quantities of rock debris swept down the Ohio valley, filling it seasonally, if not continuously, with water above

the level of 430 feet A.T. The highest water reached at least to 440 feet. The water level was high not only because of the great volume of water in the Ohio itself, but because, at the same time, the Mississippi was flooded with glacial water which tended to back up or pond the water of the Ohio on the broad flood plains of Pleistocene time. All the streams tributary to the Ohio had the lower parts of their valleys submerged by back water forming long, sinuous, shallow lakes of relatively quiet water into which silts and sand drifted from the river and from their own drainage basins. Ice containing rock debris floating down the river was carried by the wind or current up the tributaries, often for many miles, where it melted, letting its pebbles drop into the finer sediments on the bottom of the ponded valley. The total absence of glacial markings on these water worn, ice carried pebbles, some of them ten inches in diameter, suggests that they were river gravels carried by river ice rather than by ice directly from the glacier. The large number of these pebbles and their great distance up the tributaries, especially in Clover Creek, seems to call for some extraordinary method for getting the floating ice up the creek valleys. It is suggested that if the ice were river ice, which seems most probable, the rivers and the glacier were frozen up during the cold season of each year and because there was little or no melting during the winter the water in the river was low. The river froze over, much of the rock

material in its bed freezing into the ice. When the thaw came, the ice, carrying the included gravels, broke up rather suddenly and a tremendous flood resulted. As the front of the flood waters passed the valleys of the tributaries, it found them comparatively empty, so that the water bearing its burden of ice rushed up the tributary valleys for a considerable distance before they were filled to the level of the top of the great flood in the main valley.

Doubtless some of the valley filling belongs to the Illinoian and some to the Wisconsin, but it would be difficult to determine how much of the total thickness to assign to each stage.

Another deposit of Quaternary time and of glacial origin is the loess blown by the wind from the river flats in periods of low water during and after the Pleistocene. The loess in Cannelton Quadrangle is the same as that found all along the lower Ohio and Mississippi valleys. Erosion, subsequent to deposition, has swept away the loess from the surface of most of the area, but it still remains in certain protected places, thickest on hills near the flood plain and thinning rapidly away from the river. The thickest section observed is on the road in the first hill southeast of Skillman where more than fourteen and a half feet of loess occurs.

Recent Alluvium

The Pleistocene Valley filling changed the pre-

Pleistocene valley profiles, and for this reason the deposition of alluvium at the junction of the slopes and the flat surface of the filling, on the sides and at the heads of the valleys must have continued for a long time after the recession of the glacial waters, and may still be in progress in some places. Trenches and terraces cut into the Pleistocene filling frequently have been partly refilled and the rivers are continually silting up some parts of their courses and excavating other parts. It would be possible to map the Pleistocene and the recent alluvium as separate units.

CHAPTER IV
Structural Geology

Introduction

Data for structural contour maps of Fordsville and Cannelton Quadrangles were secured at the same time the areal mapping was executed. Using the thin, persistent, easily recognized Menard limestone as a datum plane, a large number of well distributed and carefully determined elevations were secured, during the process of the mapping, by the use of two anaeroid barometers and a hand level. Outcrops within the area are plentiful and the true dip is easily determined in nearly all localities. The determination of the direction and amount of throw of the faults is fairly difficult, especially in the Pennsylvanian terraines where the same kind of rock is involved on both sides of the faults.

The structural map and cross sections of Fordsville quadrangle have been overprinted on the areal geological map and published by the Kentucky Geological Survey but the Cannelton maps are still in the manuscript stage.

The contoured horizon is the base of the Menard limestone, chosen because of its persistence, wide distribution, frequent outcrops, and ease of recognition. The structural contour interval on the maps is ten feet.

The original attitude of the several units in the stratigraphic column of the Fordsville and Cannelton quad-

rangles was nearly or quite horizontal, and each unit was originally deposited as a continuous, blanket-like formation covering the entire area. The present lack of horizontality of these beds and their lack of continuity in places has been produced by movements of the earth's crust and erosion, subsequent to deposition.

Structural Relations

Fordsville and Cannelton Quadrangles lie far down on the western flank of the Cincinnati Arch and on the eastern edge of the Kentucky-Indiana-Illinois Coal basin. This location in the larger structural features of the Ohio Valley is responsible for the moderately steep southwest regional dip which is interrupted only by local irregularities and folding and faulting in the northwestern and southern parts of the area.

Faults

General Statement

The general southwestward dip of the strata throughout Fordsville and Cannelton Quadrangles is modified slightly by a few broad, low westward plunging folds which locally produce a northwestward or a southward dip. The main interruptions of the regional dip occur across the southern end of Fordsville Quadrangle, and the northwestern part of the Kentucky portion of Cannelton Quadrangle, where the structure is more or less complicated by faulting and folding.

In general, the rocks involved in the southern zone of faulting and folding are well exposed and with a good knowledge of the lithologic characters and paleontology of the Chester series of this region it is not difficult to work out the structure. The northwestern faults are likewise easy to locate in the northern part of their courses, where the Chester beds and the Pottsville conglomerate are involved but, farther to the southwest, where they enter wholly into Pottsville shales and sandstone, they are extremely hard to follow.

The Rough River Uplift

Historical

The existence of the Rough River Disturbance was discovered by Owen¹ about 1855, but he apparently did not recognize its full importance, trace it for any distance or determine its nature. He mentions it as the "Barnett's Creek Disturbance". It was investigated to some extent in 1874-76 by Norwood², who first gave it the name of "Rough Creek Uplift". Gardner³ made a reconnaissance study of the Ohio county portion of the disturbance in 1910. Various other geologists, including Glenn⁴, have made a more or less cur-

1. David Dale Owen, Kentucky Geological Reports, Old Series, Vol. 1, p. 147, Kentucky Geological Survey.

2. Charles J. Norwood, Geology of a Part of Ohio County, Part V, Vol. V. Kentucky Geological Survey.

3. James H. Gardner, Economic Geology of Hartford Quadrangle, Kentucky Geological Survey, 1910.

4. Leonidas Chalmers Glenn, The Geology and Coals of Webster County, Kentucky Geological Survey, Series VI, Vol. 5, 1922.

sory examination of this zone of disturbance during the last twenty years.

During the field season of 1926 the present writer made a reconnaissance study of this structure from the town of Leitchfield in Grayson County to the eastern margin of the Sutherland Quadrangle in Ohio County, a distance of about 45 miles. The results of this study are embodied in an unpublished paper in the files of the Kentucky Geological Survey. Since Rough Creek has been dignified by the title of Rough River on the topographic atlas of the United States Geological Survey, and since uplifting of strata is the most prominent feature in the structure throughout much of its extent, the name Rough River Uplift is here proposed for the zone of disturbance, at least from Webster to Hart Counties.

Extent. The Rough River Uplift may be connected with the Irvine and Kentucky River fault zones in eastern Kentucky, in which case it extends on to the eastward and north-eastward into West Virginia and Ohio, but this has not been definitely proven. Certainly it extends as far east as the western border of Hart County. It has been traced Westward continuously to Webster County and the structure which extends on across Webster and Union Counties and into southern Illinois at Shawneetown is doubtless a continuation of it. The fault bifurcates in the southeastern corner of Fordsville Quadrangle and one branch of it, the Locust Hill Fault,

extends northeastward across Breckinridge county into Meade county. Throughout most of its course the Rough River uplift is a great broken anticline which reaches its climax in a large broken dome a few miles northwest of Leitchfield. The faulting is mainly of the normal type, but there is some evidence of thrusting in certain localities. An area of only a few miles in width extending across the southern margin of Fordsville Quadrangle is affected by the disturbance. Its effects end abruptly north of the fault zone which borders the northern flank of the uplift.

Character of the Structure. In general, the Rough River Uplift within Fordsville Quadrangle is a very conspicuous anticline, bordered on the north by a narrow fault zone, including several small fault blocks, most of which are horsts. The crest of the fold usually lies less than a mile south of the fault zone. The beds dip steeply from the axis to the faults on the north and with about equal steepness toward the south.

It is not a simple anticline. The axis follows a rather sinuous course, and the crest is repeatedly interrupted by saddles and domes. A dome about one mile long, broken by a small fault, occurs on the crest of the anticline near the western margin of the quadrangle.

A narrow saddle, on the east side of which an anticline or dome six and one-half miles long rises with its high-

est point on the western end is present along Cane Run. Another saddle crosses the uplift on Mistaken Creek and three-fourths of a mile southwest of Yeaman a small dome with its long axis running northwest-southeast rises with a closure of 70 to 80 feet. East of this another low saddle and a small dome break the regularity of the fold. The easternmost evidence of the structure in the southeastern corner of the quadrangle is the northern portion of a fault block in which the strata dip to the northwest 360 feet in a distance of one and one-sixth miles.

All the features mentioned above are superimposed upon the greater anticline or fold. Some idea of the magnitude of the fold may be gained from the following figures: Along a line from the point of junction of the eastern border of Olaton Rectangle with the southern margin of the quadrangle northeastward toward Fallen Rock School, the strata rise 450 feet in a distance of one and seven-eighths miles, and then decline 350 feet in a distance of seven-eighths of a mile. From the same point on the southern border of the quadrangle the beds rise 600 feet in four and one-half miles to the top of the dome three-fourths of a mile southwest of Yeaman. Between the middle of the southern margin of Olaton Rectangle and the top of the anticline directly north of this point, there is a dip of 440 feet in two and one-half miles. This folding resulted in a slight shortening of the earth's surface which may have been counterbalanced by lengthening in

the fault planes. Southward, beyond the southern border of Fordsville Quadrangle, the dip evidently decreases rapidly and conforms again to the southwestward regional dip. North of the fault zone there is very little folding, the contour lines of the regional dip coming right up to the narrow drag zone without bending.

The western two-thirds of the fault zone is relatively simple, consisting of one main fault with four offshoots, one cross fault in the elongate block in the central part of the Hites Falls Rectangle and one small parallel fault just south of the main line near the western margin of the area. The small offshoots on Brown's Creek and near Davidson Station outline wedge-like segments which have moved downward hinge fashion with the greatest movement at the tip of the wedge or at the junction of the offshoot with the main fault. The two faults which leave the western margin of the area near New Baymos School probably enclose a long narrow fault block which has an upthrown northern edge and a downthrown southern portion.

The long oval fault block south of Fallen Rock School in Hites Falls Rectangle is a horst with the strata dipping so steeply to the north that four formations, Golconda, Hardinsburg, Glen Dean, and Tar Springs are exposed on a flat surface in a distance of one-fourth of a mile. A short cross fault cuts the eastern tip off this block. There is some inconclusive evidence of another side fault to

the south of the last named fault block. In the western two-thirds of the fault zone all the formations from the Golconda upward are involved in the faulting.

The eastern one-third of the Rough River fault zone is broken up into nine fault blocks. Four of these blocks are between the main Rough River Fault and the Locust Hill Fault which diverges to the northeast about one-half mile west of Yeaman. All four of these are downthrown blocks tilted toward the northwest. The throw along the Locust Hill Fault increases as it approaches the Rough River Fault. The northward dip in the large block or area in the angle between the Rough River and Locust Hill Faults is steep, amounting to 280 feet in three miles. The blocks, including Tousey and Yeaman, at the apex of the angle between the two faults are the most deeply dropped blocks along the zone. The Tousey block brings Pottsville down against Rensault in the block on the south, a vertical displacement of approximately 500 feet. Locust Hill Fault is an ordinary tension fault with the downthrow on the southeast side.

The five fault blocks which lie south of the main Rough River Fault are upthrown blocks or horsts, and all have northward dips, except the small block in the hill just east of Tousey, which dips steeply toward the east, and the eastern tip of the long sub-oval eastern-most fault block in which the dip is reversed on the two sides.

The disturbance is more intense in the southeastern corner of the quadrangle, because of the junction of the Locust Hill and Rough River Faults and because this locality is on the western flank of the dome which lies just to the east in the next quadrangle. The dome probably represents the climax of diastrophism along the Rough River Uplift.

The throw along the faults is nowhere very great and commonly is slight, especially on the side and cross faults. The maximum throw between some of the fault blocks in the eastern part of the zone is approximately 500 feet. Along the Locust Hill fault, after the apical fault blocks are passed, the throw varies from 20 feet to 150 feet within the quadrangle and seemingly increases very rapidly beyond the eastern margin of the quadrangle so that about a mile northeast of Shady Grove Church, Pottsville on the east is thrown against Golconda on the west, indicating a throw of 250 feet. In the two places where the Rough River Fault Zone is reduced to a single fault, the throw is 100 feet and 200 feet with the downthrow on the north. Wherever observed the fault planes dip very steeply, a dip of 85 degrees being usual. Narrow drag zones and slickensides on the sandstones are common. Mineralization occurs in some of the faults and fractures. Lead and zinc sulphide occur in small quantities in a fault just south of the southeastern corner of the area and large quantities of calcite are present on Mistaken Creek. However, the possibility of commercially important mineral de-

posits in these faults is remote.

Origin. All the evidence along the Rough River Uplift indicates that compressive force was responsible for the disturbance, the folding and faulting probably resulting from the same pressure. There are two possibilities: first, the fold was formed by compression and later tension caused the northern flank of the fold to break and drop to its former position by normal faulting; second, compression from the south produced the fold and lifted the southern walls of the faults up along the fault planes while the northern walls remained essentially stationary. The field evidence favors the latter theory, which is in harmony with the findings of Glenn⁵ in Webster County.

The origin of the pressure which resulted in the uplift is conjectural, but the following hypothesis is suggested. At some time after the early Pennsylvanian, the western Kentucky Geosyncline or coal basin was formed by down warping. This down warping produced lateral pressure on its flanks. The Rough River Region, lying parallel to the axis of the geosyncline was folded, broken, and pushed upward by this pressure. An alternative hypothesis is that it is the result of the same movement of magma that produced the complex fault system and igneous dikes farther west. In the latter case, almost all the faults in western Kentucky and southern

5. L. C. Glenn, The Geology and Coals of Webster County, Kentucky Geological Survey, Series VI, Vol. 5, 1922.

Illinois are related in time and mode of origin, but this area is too far from the region where igneous dikes and other evidences of magmatic movements occur to warrant this conclusion and it is more probable that the Rough River Uplift had its origin in the adjustments which accompanied movements on the Cincinnati Arch and in the western Kentucky Coal Basin.

The determination of the date of folding and faulting is a greater problem even than that of the origin, but the most probable time was that of the Appalachian Revolution, which came near the close of the Paleozoic.

Indian Creek and Hawesville Faults

Indian Creek Fault. The Indian Creek Fault crosses Ohio River one and one-half miles northwest of Skillman Station and trends approximately south 27° west through Shafer Hill. It crosses Highway 60 four-fifths of a mile east of Indian Lake, traverses the headwaters of Caney Creek, and leaves the quadrangle just south of Blackford Creek. Evidently the fault extends to the northeast across Ohio River into Indiana, but southwestward it seemingly ends a short distance beyond the western margin of Cannelton Quadrangle.

The name Indian Creek Fault is given to this structure because of the striking and peculiar evidences of its presence which are found in Shafer Hill and the knobs and ridges on either side of Indian Creek and Highway 60. It is clearly a tension fault with the plane dipping at a high

angle, 85° or more. The downthrow is on the northwest with a maximum throw on Indian Creek of approximately 200 feet which is gradually reduced to zero just beyond the western margin of the quadrangle.

Several peculiar features in connection with this fault are worthy of mention: First, it should be noted that "Rock Island", which is in Ohio River just west of the fault, is not due to the fault but is the result of a great landslide of Pottsville conglomerate over Buffalo Wallow shale from the point of the nearby bluff on the Indiana side of the river. The conditions which occur in Shafer Hill are exceedingly interesting. The hill is the site of a hinge on the fault line. On either side of the hill, the throw along the main fault is about 200 feet, but where the fault crosses the hill there is probably very little or no throw on the main fault; instead a short fault diverges to the northwest from the main fault along either side of the hill. The throw on these side faults changes from 200 feet to 0 within less than half a mile, leaving the small block which includes Shafer Mill inclined at a high angle against the wall of the main fault while the strata on either side of the hill are dropped two hundred feet. The dip in this block is approximately two hundred feet in two-fifths of a mile.

South of Indian Creek and Highway 60 the fault extends west of the points or knobs on the east side of the ridge. These points stand out in high, bold, perpendicular

cliffs of basal Pottsville conglomerate overlying Buffalo Wallow shales and limestones. Ridgeward the conglomerate abuts against relatively weak Pottsville beds on the down-throw side of the fault. Between the points the ravines cut entirely through the conglomerate and head in the softer materials beyond the fault, isolating the inter-ravine blocks of conglomerate.

Southward from about one and one-half miles south of Highway 60 the fault is difficult to trace. The next good check on it is in the head of Caney Creek where Dejarnett's mine is opened on the Hawesville coal at an elevation of 495 feet A.T. while an old mine on the same coal in a hilltop one-half mile to the east is at 620 feet elevation, indicating a throw at this point of 125 feet.

On the head of the first small stream north of Blackford Creek the Hawesville Coal dips steeply and slickensides occur in the gap in the ridge between this stream and Blackford Creek, but the amount of throw at this point could not be determined.

Hawesville Fault. The presence of a fault just east of the town of Hawesville was discovered many years ago in connection with the mining of the Hawesville coal and mention of it appeared in the earliest literature of the Kentucky Geological Survey. The Hawesville Fault crosses Ohio River just above the Hawesville-Cannelton Ferry and trends approxi-

mately south 27° west just east of the city limits of Hawesville. Only about half a mile of its course lies within Cannelton Quadrangle, but it certainly extends as far south as Lead Creek and possibly considerably beyond. The exposures of the Pottsville Conglomerate end abruptly in the eastern or foot wall of this fault. The steeply dipping, slickensided fault plane is exposed on the Hawesville-Hartford Road at the top of the hill just south of Highway 60, but the best evidence of a fault here is found in the displacement of the Hawesville coal. At an old mine on the hill just east of the fault the Hawesville coal is at an elevation of 530 feet A.T. About 200 yards west of this location, on the edge of Tell City Quadrangle, the coal is at 420 feet, indicating a throw of 110 feet, but the actual vertical displacement is doubtless considerably less than this because the drag zone, especially on the downthrow side, is long and steep.

Both the Hawesville and Indian Creek structures are tension or normal faults, doubtless resulting from adjustments due to movement in the Cincinnati Arch and the Western Kentucky-Illinois Geosyncline. They are modifications of the regional dip where, instead of distributing the drop of strata over several miles of regular regional dip, much of the drop is taken up abruptly in two faults.

The strata in the block between the Indian Creek and

Hawesville Faults are remarkably level, there being a westward dip of only about forty feet in the distance of three miles between them.

At two other places, one in the head of a valley one and a half miles north of Patesville, and the other in Bates Hollow in the northwest corner of Fordsville Quadrangle, some evidence of faulting occurs, but the presence of faults could not be established. The features noted may have been due to the movement of unconsolidated Pottsville sediments in early Pennsylvanian time as indicated below.

Slumping and Creeping

Slumping or landslides on the steep slopes along the streams of the region is a common phenomenon, but it is developed to the greatest extent at the points where Ohio River is undercutting its bluffs, as it is both northeast and northwest of Cloverport and above both Stephensport and Hawesville. The Louisville and Nashville Railroad Company has experienced considerable difficulty in preventing its tracks from being carried away by landslides. On many of the slopes, where resistant beds of sandstone or limestone are underlain by shale, slumping takes the form of slow creeping of blocks of the resistant rock downward over the shale.

Early Pottsville Slumping

A peculiar form of slumping occurred locally in the

movement of unconsolidated sediments in the pre-Pottsville valleys in early Pennsylvanian time. This phenomenon is best displayed on Caney Fork of Adams Creek, one mile north of Oak Station, where most of the features associated with faulting occur in the Creek bluff. However, a close study of this locality leads to the conclusion that the disturbance of the basal Pottsville beds occurred prior to their consolidation and that the observed disarrangement of the blocks of Buffalo Wallow limestone was effected by slumping on the pre-Pottsville surface. Evidently lateral pressure, developed by compaction or by unequal sedimentation, was exerted on the unconsolidated sediments in the partly filled valleys of early Pottsville time. The buried hills of the pre-Pennsylvanian surface acted as buttresses against this pressure and caused the loose sediments to be bent and contorted against their sides. The sediments were subsequently indurated, retaining the structure developed in them before their consolidation. False dips, even on coal beds, and undulating and contorted bedding observed in several localities were evidently produced in this way.

CHAPTER V
Historical Geology
Introduction

The records of events which have transpired in the geologic past are preserved in two different manners. A region depressed below the base level of erosion keeps a record of events in the sediments deposited upon it and an area elevated above the base level has the record of passing events carved into its rocks by the agents of erosion. The geological history of any region is therefore interpreted from its stratigraphy and its topography. Since the rocks in the Fordsville and Carmelton Quadrangles are all of sedimentary origin and mostly marine, a treatise on the geologic history of the area is concerned mainly with the changes in distribution of land and water during the various stages of time involved and with the diastrophic and erosional changes which have occurred since deposition of the youngest consolidated strata in the area.

Although the oldest exposed formation in the region is the Ste. Genevieve limestone of the upper middle Mississippian epoch, something of the history of still more remote geologic times may be learned through observation of formations exposed in adjacent areas and through data supplied by deep well drillings.

Paleozoic Era

Ordovician Period

The deep well, drilled in 1921 at Victoria, seven miles south of Cloverport, probably penetrated all the geological horizons exposed anywhere in the state of Kentucky from near the top of the Chester Series of the Mississippian System downward. The lower 1005 feet of strata penetrated by the drill hole has been identified as of Ordovician age and the lower part of this interval is evidently in the High Bridge limestone which belongs to the middle Ordovician and therefore to the oldest rocks exposed in Kentucky. The drill cuttings reveal the presence of more than a thousand feet of Ordovician limestone of varying colors and textures. This extensive limestone series implies a clear open sea remote from rugged lands. That its genial waters abounded in animals of the sea is proved by the abundance of fossils embedded in the strata where they crop out in central Kentucky. From a study of the Ordovician rocks of North America we know that during middle and upper Ordovician time the continent was probably more widely covered by epicontinental seas than at any other time in its history, the maximum submergence in the middle Ordovician covering at least sixty percent of the present area of North America. The shallow seas oscillated greatly in areal extent during the period and at its close withdrew from most of the North American continent.

Silurian Period

In the Victoria well 170 feet of yellow and white limestone is referable to the Silurian System. The presence of limestone implies that the sea again ruled in this part of the state as it did in other wide areas of North America, but the impurities found in the limestone indicate that conditions were not so settled and the rule of the sea was not so secure as in the Ordovician. It was at this time that the Cincinnati-Arch first came into existence as an island.

Devonian Period

A long interval of land conditions and erosion must have existed between the Silurian and the time of deposition of the oldest Devonian rocks, which evidently belong to middle Devonian time. The lower formation of the Devonian system is composed of dolomite or magnesian limestone, indicating deposition in relatively clear seas considerably removed from areas of high land. After the deposition of this limestone the land was emergent in many parts of Kentucky and elsewhere, with the result that the upper part of the formation in many localities was rendered porous by weathering. This condition made possible the accumulation of petroleum in the rock and the formation of the famous "Corniferous" oil sand. Whether this occurred in Fordsville and Cannelton Quadrangles has not been definitely proven.

The Devonian limestone is succeeded by 198 feet of

dark brown to black carbonaceous shale. The conditions under which this mechanically formed sediment accumulated were very different from those under which the underlying limestone was deposited. The sea must have been more restricted, nearby land must have furnished the sediment, and conditions must have been favorable for the existence of abundant plant life to supply the carbonaceous material.

Mississippian Period

Osage Epoch

The character of the New Providence shale and the thickening of the formation from west to east suggests that it was derived largely from the erosion of land at the top of the Cincinnati Arch and laid down in a shallow oscillating sea.

The New Providence shale is succeeded by limestone which implies that the seas were growing broader or that the sediment producing lands were growing lower or more distant, but the argillaceous nature of much of the limestone indicates that the Cincinnati Arch was still contributing some sediment to this area.

Meramec Epoch

The Osage Epoch is followed, probably without a break in the marine sedimentation, by a thick series of relatively pure limestones. The epicontinental seas must have been widely extended and the lands surrounding them too low to

send much clastic sediment into the seas. The abundance of corals and other marine forms indicates a mild climate.

The conditions mentioned above continued until after the deposition of all of the Ste. Genevieve limestone now present in this area, when general emergence and sub-aerial erosion occurred throughout the Ohio and upper Mississippi valleys.

Chester Epoch

With the beginning of upper Mississippian or Chester time, oceanic waters again occupied much of the Mississippi and Ohio valleys, but the pattern of the seas of this epoch was quite different from those of earlier Mississippian times and the conditions controlling sedimentation were notably different from those which obtained during the earlier part of the period. A series of advances and withdrawals of the epeiric seas during the Chester epoch resulted in the deposition of an alternating series of sandstone and limestone-shale formations, the abundance of clastic materials being in contrast with the dominantly calcareous sediments of the earlier Mississippian.

The land masses bordering the waters were relatively higher and the seas more restricted in depth and areal extent than formerly. The result of these different conditions was the transportation to the seas by the streams of much more mechanically derived sediment which formed the sandstone

and shales of the Chester Series. At irregular intervals the waters became deeper and marine organic sediments were interbedded with the clastics.

The alternation of limestone-shale and sandstone formations in the Chester implies stages of deeper and broader waters alternating with stages of shallower and narrower seas. When the water advanced upon the land a stage of sandstone deposition was inaugurated and as the water spread and deepened there was ushered in a stage of shale and limestone deposition. Thus there was developed a series of pairs of formations, each pair consisting of sandstone below and limestone-shale above.

In some of these oscillations the water was completely withdrawn from this area, a condition which is shown by the erosional disconformities between some of the formations. At other times the transition from limestone to sandstone formation was gradual, showing that the withdrawal of the sea was not complete, and that the change from one type of sediment to the other occurred without a complete interruption in sedimentation. These changes in the relations of land and water may have been due to successive elevation and depression of the interior lowland of North America.

In southern Illinois and on the western margin of the Western Kentucky Coal Basin, the Chester Series comprises seven pairs of alternating sandstones and limestones (including shales) and a basal limestone, 15 distinct formations.

Slight erosional disconformities occur between each successive pair and above the basal limestone. Each pair of formations lying between two disconformities marks a stage in the Chester Series. However, only six of these pairs are present in the Fordsville and Cannelton quadrangles, and there are only four recognizable disconformities which divide the Chester Series into five stages. The oscillations in which the retreat of the seas was not complete are regarded in this report as sub-stages.

Aux Vases - Renault Stage. The oldest Chester formation of the Mississippi Valley section is the Aux Vases sandstone, but this formation is not present in west central Kentucky. Either this area was land and was subject to erosion while the Aux Vases sandstone was being deposited elsewhere or the lower part of the Renault limestone in this region is the time equivalent of the Aux Vases sandstone farther west. Lands capable of sending much rock waste to the sea were remote from Fordsville and Cannelton Quadrangles in Renault time, but at the close of the stage the waters withdrew sufficiently to allow the production of a pronounced erosional disconformity before the abrupt beginning of deposition of the overlying Bethel sandstone.

Bethel - Paint Creek - Cypress - Golconda Stage. This stage includes two sub-stages or two pairs of formations because the field evidence favors belief in a continuance of

sedimentation without a break from Paint Creek into Cypress time.

After the post-Renault erosion the waters returned and an abundance of sand produced the Bethel sandstone. As the sea gradually widened and deepened the character of the sediment changed through shale to limestone. Shifting currents or oscillating seas caused the inter-stratification of limestone and shale in the Paint Creek formation and a partial retreat of the sea or a slight uplift of the bordering land made it possible for the streams and currents to transport into the area the sand and mud of the Cypress formation. As the seas again slowly widened, the soft shales and fine sands of the lower Golconda gave way to the Golconda limestone, the deposition of which was continued until the strand line again retreated beyond the area and sub-aerial erosion was active for a short time.

Hardinsburg-Glen Dean Stage. Evidently this was a regular Chesterian stage of deposition, the rocks consisting of one pair of formations set off by erosional disconformities at the top and bottom. After a short and slightly effective post-Golconda erosional interval, the sea returned and deposition of sand brought into it by the streams from the bordering land areas formed the Hardinsburg sandstone.

The advancing sea pushed far enough to the north to prevent the mingling of near shore sandy sediments with the

accumulating limestone, although much fine clay was introduced. The sea was similar in general to that which prevailed during Golconda time and limestone was again deposited. The shale interbedded with the Glen Dean limestone is suggestive of the recurrence at intervals of conditions favorable for the transportation of mud into this region.

Tar Springs - Menard - Palestine - Clore Stage. After the culmination of Glen Dean time, the sea again retreated and a change from conditions favorable for the accumulation of more or less pure limestone to conditions under which more clastic materials were deposited began with the deposition of the Tar Springs sandstone upon the eroded surface of the Glen Dean. The great lateral and vertical variations in character and thickness of the Tar Springs formation suggests that it was deposited either by streams meandering over mud or sand flats or by currents and eddies in shallow water. After a time deposition in this area seems to have been counterbalanced by transportation and thus the upper surface of the Tar Springs stood at base level without further deposition or erosion while a complete pair of formations, the Vienna-Waltersburg, was being deposited farther west. However, there is a possibility that beds equivalent in age to these formations may be present in the lower portion of the Menard limestone. Eventually, further submergence permitted the deposition of the Menard limestone and as the water

shallowed the character of the material gradually changed through shale to the sand of the Palestine sandstone, but the stage was not completed by the introduction of an erosional interval although the presence of plant fossils in the Palestine implies that abundant vegetation grew nearby. Almost immediately the water began rising once more and conditions favorable to the deposition of the Clore limestone and shale returned.

Degonia-Kinkaïd Stage. There is considerable evidence that part or all of the two quadrangles under consideration was subjected to erosion at the close of Clore time, after which the sea again returned bringing the usual load of sand which became the Degonia beds. This last recorded advance of the Chester seas became very extensive and sediment producing lands were so distant that the deposition of thick beds of relatively pure limestone was made possible.

The question in regard to the sources of the clastic sediments of the various Chester formations is one which cannot be satisfactorily answered at present.

Pennsylvanian Period

General uplift at the close of the Mississippian period produced emergent lands throughout eastern North America. The vertical uplift in the region of northwestern Kentucky and southern Indiana was not great, but still suf-

ficient to allow erosion to dissect the area into a moderately rugged topography.

Far to the east of Fordsville and Cannelton, doubtless in old Appalachia, important changes had taken place which resulted in the spreading of enormous quantities of coarse sediments westward into the Mississippi Valley. Valleys directly on the main lines of advance of these sediments were filled with coarse sand and conglomerate, while other valleys and lowlands isolated by their position in the topography of the time received only fine materials. Numerous changes in level, in which the aggregate of downward movements undoubtedly exceeded that of the uplifts characterized Pennsylvanian time. This fact made possible a long continued influx of sediment from the east, although the quantity and character of the sediments varied greatly from time to time and from place to place. Eventually the pre-Pennsylvanian topography was deeply buried and Pennsylvanian sedimentation continued in this region to a great but unknown depth.

This area, like most other portions of the eastern half of the United States, in Pennsylvanian times, remained close to sea level, at times slightly submerged and subject to marine sedimentation, at other times enough above the level of the sea to be the sites of fresh water marshes in which coal forming material accumulated.

Since Pennsylvanian time this area has not been depressed beneath the sea, although it may have stood but little above sea level during long periods.

Post-Pennsylvanian Diastrophism

Over most of the area of Fordsville and Cannelton Quadrangles the Mississippian and Pennsylvanian strata which were originally nearly horizontal are now dipping rather steeply toward the southwest, and the regular dip is frequently modified by broad, low westward-plunging folds. Across the southern end of Fordsville Quadrangle there lies a conspicuous zone of faulting and folding and in the west central portion of Cannelton Quadrangle two important faults cut the strata. The age of the disturbance which produced these features constitutes one of the unsolved problems of geology. It can be dated only within very broad limits, between the close of the Pennsylvanian and the beginning of the Cretaceous period, but geologists, generally, are inclined to think that it was associated with the Appalachian Revolution, which came after the close of the Pennsylvanian and which affected more or less all the eastern half of the United States. At this time the Cincinnati Arch was uplifted notably and probably the Western Kentucky Coal Basin received its initial depression. The faulting and folding was likely due to minor adjustments necessitated by these major movements. The features resulting from diastrophism are probably the only

records of the Permian period in this region.

Mesozoic Era

Triassic and Jurassic Periods

No deposits of any kind in Fordsville and Cannelton Quadrangles are referable to the Triassic and Jurassic periods and no topographic features, developed during these periods, are in existence today. For these reasons it is impossible to learn much about the history of the region during that time, but it may be assumed that the entire area was continuously dry land.

Cretaceous Period

No deposits known to be of Cretaceous age exist in this area and it is doubtful if there ever were any, but during the Cretaceous period a peneplain was developed throughout the entire eastern part of the United States. Remnants of this Cretaceous peneplain in the form of more or less isolated knobs and ridge tops have been preserved in both of the quadrangles.

Genozoic Era

Tertiary Period

At some time in the Tertiary period a series of uplifts, each of which rejuvenated the streams and stimulated erosion began. There is some evidence of four uplifts of

about 100 feet each, and three are quite clearly indicated. This is in agreement with earth movements in the Tertiary in other parts of the Ohio Valley, east as well as west of the Cincinnati Arch. For example, in Madison County, Kentucky, there are three peneplains or terraces, including the Cretaceous peneplain, and Kentucky River is now doing the initial work on a fourth erosion surface. Ancestors of Rough and Ohio Rivers were following the main valleys of Fordsville and Cannelton Quadrangles in Tertiary time much as they are now, making deposits of sand, clay, and gravels of comparatively local origin.

Quaternary Period

The erosion which cut below the youngest terrace mentioned in the discussion of the Tertiary may have been accomplished partly or entirely in the early part of the Quaternary Period, and the reason for it may have been an increase in the volume of Ohio River, rather than rejuvenation by uplift.

An important problem is involved in the age of the Ohio river. Field evidence supplied by deposits and topography indicates that a river, during most or all the Tertiary and perhaps for a long time preceding the Tertiary, followed essentially the present course of the Ohio and in the same direction. However, the sediments deposited by this forerunner of the Ohio suggest that the river was not a long one,

at least it did not head far enough east to bring sediments from igneous and metamorphic sources in the Appalachians. Even the very latest Tertiary sediments contain no trace of igneous and metamorphic materials. Evidently water from what is now the upper valley of the Ohio first began to flow westward near the beginning of the Pleistocene when early glaciation began to disturb the drainage systems.

During the later stages of the Pleistocene great floods of glacial waters bearing enormous quantities of rock debris swept down the Ohio Valley, filling it at least a hundred feet deep with gravel, sand, and silt. The water and deposits along the main valley caused ponding in all the tributary valleys. In the quiet waters of the ponded streams, sediment settled to fill the tributary valleys to or above the top of the filling in the valley of the river. To supplement the fine sediments of the ponded valleys ice cakes drifted in, carrying more or less gravel which they, upon melting, dropped. The latest Pleistocene may have witnessed some reexcavation of these valley deposits.

Recent

Since the Pleistocene some portions of the valleys have undergone further aggradation, especially in their upper courses, and along the flanks of the Pleistocene flats. Elsewhere the streams have been actively engaged in trenching the valley filling. Since the coming of man and the destruc-

tion of the forests, both erosion from the higher lands and deposition along the valley floors have been increased.

CHAPTER VI
Economic Geology
Introduction

The portions of Breckinridge, Hancock, Ohio, and Grayson Counties which are included in Fordsville and Cannelton Quadrangles are fairly well supplied with mineral resources, possibly ranking above the average of Kentucky counties in this respect. The economic resources include soil, petroleum, natural gas, rock asphalt, coal, clay, stone, marl, cement materials, sand and gravel, ground water, water power, and natural scenery.

Soil

The limestones and marls of the Chester Series are well supplied with plant food materials and sandstone and shale almost always occur in such close proximity to each other that their mingled products serve to counteract the excessive porosity of the one and the undesirable compactness of the other. The upland soils from the Pennsylvanian sandstones and shales are fairly good if the surface is smooth enough to prevent rapid erosion, while the soil of the broad flood plains or flats along the valley bottoms, composed of rich glacial silts and the best of the soil washed from the local slopes, is excellent when properly drained.

Slopes are steep over much of the area and although

the virgin soil on these slopes may be rich, it is soon washed away when the forest covering is removed. Agriculture should be confined largely to the relatively flat uplands and valley bottoms. Large scale drainage projects have reclaimed most of the wet bottom land of the larger valleys and individual or small groups of farmers have drained most of the smaller swamp areas.

The usual crops of this part of the Ohio valley are grown here. At the present time the rather large scale production of cucumbers for the manufacture of pickles forms an important special crop.

Petroleum

The springs at Tar Springs and Little Tar Springs have been producing small quantities of petroleum since prehistoric times. Prior to 1925 very few holes had been drilled for oil in this area, but at about that time discoveries in the region to the south and west of Fordsville and Cannelton Quadrangles precipitated a period of almost feverish prospecting which did not lessen until the petroleum industry was seriously affected by the period of economic depression starting in 1929.

Prior to the early part of the summer of 1931, 161 holes had been drilled in Fordsville Quadrangle and 69 holes in the Cannelton. The total cost of prospecting in the two quadrangles probably lies between a quarter and a half

million dollars.

Lists of all drill holes in the two quadrangles, including the names of the lessors and lessees, the casing head elevations, the depths, the sands, and the results of the prospecting are on the backs of the maps. The locations of all drill holes are indicated by the proper symbols on the faces of the maps.

The results, not counting gas which in nearly all cases was not the object of the drilling, were 163 dry holes, 32 holes with a showing of oil, 13 small producers which never paid and were soon abandoned, and 22 small to moderate producers, which were still pumping when visited in 1931. A flush production of 150 barrels was reported from one or two wells, but in general a 20 barrel pumper is considered very good for this area and few of them make that much. The producing wells are all in five small pools. The above figures indicate that the chances for drilling a producing well, especially outside of proven territory, are considerably less than one in ten. However, it is probable that other small pools will be discovered within the area.

There are four horizons in the Chester Series from which oil may be expected, and all of them are either producing or have given showings of oil in certain localities. The upper sand is the Tar Springs sandstone, which is usually called "Jett" or "Stray sand". This formation is commonly com-

posed entirely of shale and the sandstone occurs only locally in the form of lenses or irregular bodies of greater or lesser extent. This sand is deep enough beneath the surface for the retention of oil only in the western one-third of the area.

The second sand, at an average of about 90 feet below the upper one, is the Hardinsburg sandstone, or the "Jones sand" of the drillers. The Hardinsburg sand is producing oil on Panther Creek and the west fork of Adams Creek. This sandstone, like the Tar Springs, is also patchy, and laterally it may change to shale in all directions. The Hardinsburg is deep enough beneath the surface for oil throughout the western half of the area except in the Rough River Uplift.

The Cypress sandstone or "Jackson sand" lies about 70 feet below the Hardinsburg. In the area of outcrop the Cypress is one of the thickest and most persistent of the Chester sandstones, but for some unknown reason it has produced little or no oil, although it is frequently mentioned in well logs. Like the other Chester sand bearings formations, the Cypress gives way to shale in some localities.

The fourth and lowest Chester oil sand is the Bethel sandstone, or "Barlow sand", patchy and shaley like all the others. The Bethel has yielded oil at Victoria and near Glen Dean. This sandstone underlies a large proportion of the area at a depth sufficient to furnish a reservoir for oil. All prospect holes drilled in this area should be extended at least to the Bethel horizon.

There are no dependable oil horizons below the Chester Series, yet it is possible that oil may be found at the Chester-Meramec or Renault-Ste. Genevieve contact; at certain horizons well down in the Meramec Group or "Big Lime", and in the Devonian or "Corniferous" limestone or dolomite.

A careful study of the surface and the subsurface conditions in this area has lead to the conclusion that in general, structure has had little influence in controlling the migration and accumulation of oil in the Chester sands. Rather the extent of migration and the points of accumulation have been determined largely by changes in the lithologic character of the oil bearing formations. All the Chester sandstones, laterally, change rapidly and frequently from sandstone to shale and back to sandstone again. This condition divides the formation into lenticular or irregular shaped, porous bodies capable of containing oil, and close grained, shale bodies more or less impervious to oil. Oil can migrate only within the limited extent of the porous rock. In general, the place of accumulation is on the updip side or end of a porous body. These conditions make prospecting very uncertain and expensive. Additional small pools may be discovered from time to time but any hope of a real big strike is vain.

On the basis of structure, the folding in connection with the fault lines offers the best opportunities for oil, but unfortunately all the Chester sandstones in the great fold

south of the Rough River Fault line are at or near the surface. However, well placed holes should be drilled to the Devonian limestone along the crest of the big anticline in the Rough River Uplift.

Natural Gas

The same horizons which are yielding oil are also the ones from which gas may be expected and all the conditions affecting prospecting for oil apply likewise to prospecting for gas.

Heretofore, except for two instances, in the towns of Gloverport and Fordsville, gas has been only a by-product and usually an undesirable one of oil prospecting and production, but with the recent changes in the gas industry, this product of Fordsville and Cannelton Quadrangles bids fair to exceed petroleum in importance. Back in the 1880's about a dozen gas wells were drilled in the town of Gloverport and for several years the town and tile factory were supplied with gas from these wells, three of which were still producing in 1910. The horizon from which the gas came was evidently near the bottom of the Meramac group or the "Big Lime" of the Mississippian System. Some interesting little gas wells were drilled in the town of Fordsville during the summer of 1930. Four or five wells were drilled to the Tar Springs sandstone at a depth of about 230 feet. Each well was intended to supply one home or school. The wells were all successful not only in

securing a satisfactory supply of gas for domestic use, but each well also produces enough potable water from Buffalo Wallow sandstones to supply the homes and the school. These people obtain their heat, light, and water all from the same holes in the ground, in their own back yards.

Thirty-nine holes in Fordsville Quadrangle and nineteen holes in Canneilton Quadrangle have yielded gas. The best gas field at present is on the north fork of Panther Creek. Other promising pools are at Victoria, at Fordsville, and two miles southwest of Fordsville. There are isolated wells in several other places. The Missouri-Kansas Pipe Line Company has recently run a gas line into the area.

Rock Asphalt

The lower few feet of the Tar Springs sandstone in the vicinity of Tar Springs, at Cloverport and at Little Tar Springs are bituminous. It is possible, also, that this is true of the Tar Springs sandstone in other localities and of the other sandstone formations of the Chester Series. Although this region has not been thoroughly prospected for rock asphalt, it is believed that no deposits of this material exist which are commercially important under existing conditions.

Coal

Although there are several other thin, local seams of coal, some of which have been mined in a very small way,

within Fordsville and Cannelton Quadrangles, the Hawesville and Breckinridge coals are the only ones that are commercially important.

The Hawesville coal is of the bituminous variety and formerly occurred beneath all the ridges and uplands between the Hawesville and Indian Creek Faults, and in the tops of a few of the highest hills and ridges elsewhere in the western part of the area. The deposit was essentially exhausted north of Lead Creek in the extensive mining operations of many years ago and subsequent mining has made great inroads on the supply within the remainder of the area. The main body of unmined coal now lies between the head of Lead Creek and Blackford Creek. East of Indian Creek fault, the Hawesville is or was of workable thickness in only five or six small areas as follows: in the top of the high hill at the head of Caney Creek where it is nearly exhausted; in the ridge two miles southeast of Patesville where it is thin and shaley; in the top of the high hill one mile southeast of Fordsville where it is exhausted; in the hill one and one-half miles southwest of Fordsville where it is essentially mined out and around the head of Huff Creek and to the northeast of Narrows where small bodies of unmined coal still remain. A bed of coal reported to be twenty inches thick which is being mined for local domestic use in a ridge one and one-half miles southeast of Falls of Rough is believed to be the same as the Hawesville. Coal is being mined in a small way in all

the above localities where it is not already entirely exhausted.

The Hawesville was probably mined earliest of any coal in western Kentucky, the old Reverdy and Trabue Mines at Hawesville being among the first and the largest on the lower Ohio. Extensive mining was begun ten years or more before the Civil War and was continued actively until 1885.

The Hawesville coal was deposited on an uneven surface and for that reason varies greatly in thickness within short distances, attaining a maximum in small local basins of five feet. Three feet is probably a fair average. It is a hard, brittle coal with thin, black, lustrous bands between thicker bands of a dull appearance. It has a parting of about four inches of fibrous coal or mineral charcoal which usually contains some sulphur and locally there are a few inches of cannel coal at the top. The parting is characteristic of the bed and if reports are true there is a thickness of two feet of "bone" at the old mines one mile southeast of Fordsville. The Hawesville is overlain with dark gray shale and underlain by four to thirty inches of shaly coal or black shale which in turn is underlain by a bed of fire clay.

Hawesville coal has always been regarded by the local trade as superior to any other obtainable in western Kentucky. The percentage of sulphur is not high and it burns to a white ash with little or no clinker.

Analysis of Hawesville coal by Robert Peter, 1884.

Moisture	5.10
Volatile matter	41.20
Fixed carbon	46.60
Ash (light lilac gray)	<u>7.10</u>

Total 100.00

Percentage of sulphur	3.331
Specific gravity	1.292

The Breckinridge Cannel Coal is stratigraphically about 100 feet below the Hawesville coal. The old field at Victoria, from which this coal was mined before and soon after the Civil War, is situated about seven miles southwest of Cloverport near where the Breckinridge-Hancock County line crosses the southern margin of Cannelton Quadrangle.

The area of the workable portion of the Breckinridge coal bed was very small and the coal was completely mined out more than fifty years ago. This coal is described on page 90 of this report.

Probably no other American coal yields such a high percentage of volatile combustible matter. There was a reported production of a little over 100 gallons of crude oil per short ton of coal. About the year 1854 two companies, which consolidated a little later, were interested in this field. A plant for the manufacture of illuminating oil or "Coal oil", benzol, lubricating oils, and paraffine from cannel coal was built at Cloverport. Two ventures into this industry ended in failure.

Clay

Clay suitable for tile, sewer pipe, and brick occurs in inexhaustible quantities in the Chester Series of both quadrangles and fire clay is associated with the coal beds of the Pottsville Series. The shale beds of the Paint Creek, Golconda, Glen Dean, and Buffalo Wallow formations all produce good clay. Probably the best of all is the lower clay member of the Golconda. The following analysis of Golconda and Buffalo Wallow clay were taken from pages 767 and 768 of the First Annual Report of the Kentucky Geological Survey, Series 4, Volume 1, Part II.

Analysis of an Air-Dried Sample of Golconda Clay from Stephensport.

	Percent.
Moisture	4.03
Combined water	2.70
CO ₂	5.93
SiO ₂	49.30
Al ₂ O ₃	19.36
Fe ₂ O ₃	7.60
FeO	0.70
CaO	2.18
MgO	2.17
K ₂ O	4.93
Na ₂ O	0.04
TiO ₂	0.40
SO ₃	None
P ₂ O ₅	<u>None</u>
Total	99.34

A sample of this clay gave the following characteristics: color, brown, burned deep red at Cone 1 (2,102 degrees F.) and very dark red at higher temperatures. Taste, lean and rather free from grit. When ground to 20 mesh and mixed with 18% water it made a lean paste which stood a fair rate of drying and shrank 5% in drying and a like amount in vitrification, giving a total shrinkage of 10%. The air dried mud showed a tensile strength of 60 pounds to the square inch, with a maximum strength of 94.7 pounds. Complete vitrification occurred at Cone 2 (2,138 degrees F.) This is a drain tile and common brick clay, and may be used for vitrified brick.

Analysis of an Air-Dried sample of Buffalo Wallow Shale from Buffalo Wallow, two miles West of Cloverport.

	Percent.
Combined water	5.86
Moisture	3.04
CO ₂	1.51
SiO ₂	58.00
Al ₂ O ₃	15.06
Fe ₂ O ₃	7.36
FeO	0.50
CaO	2.36
MgO	2.69
K ₂ O	3.28
Na ₂ O	0.64
TiO ₂	0.50
SO ₃	Trace
P ₂ O ₅	<u>None</u>
Total	100.80

Ratio of iron and alumina to silica is 2.53. This should serve as a material for making Portland Cement, although the potash is a little high and the ratio at the low limit. A sample of this clay gave the following characteristics: color, green; burned to dark red at Cone 1 (2.102 degrees F.) and to a dark brown at higher temperatures. Taste, lean and somewhat gritty; when ground to 20 mesh and mixed with 20% water it made a lean paste that required slow drying and shrank $7\frac{1}{2}\%$ in drying and 10% more in vitrifying, giving a total shrinkage of $17\frac{1}{2}\%$. The air dried mud showed a tensile strength of 120 pounds to the square inch, with a maximum strength of 141 pounds. Incipient vitrification occurred below Cone 1 (2.102 degrees F.), complete at Cone 4 (3.270 degrees F.), and partially viscous at Cone 6 (2.282 degrees F.)

This clay will do for the manufacture of common brick and tile.

The Murray Roofing-Tile Company at Cloverport is the only concern in the two quadrangles using clay at the present time. The company's plant is in the northeastern part of town and the clay pit and rock quarry are about 500 yards farther to the northeast. This company makes an excellent grade of flag and roofing tile.

The clay pit which at present has a working wall 32 feet high is partly in the upper portion of the Hardinsburg formation and partly in the lower portion of the Glen Dean

formation, and is underlain by shelly Hardinsburg sandstone and overlain by Glen Dean limestone. Probably the lower ten feet of the shale in the pit belongs in the Hardinsburg and is somewhat sandy while the upper, softer, redder 22 feet of shale is Glen Dean. The limestone is quarried off the clay and crushed into macadam.

There is little possibility of the supply of Hardinsburg-Glen Dean clay being exhausted but, if it should, the company has the top of about 40 feet of Golconda shale just 50 feet below the bottom of the present pit.

The shale used by the Murray Roofing-Tile Company has excellent working qualities. The following presents a partial test of the material:

Plasticity	Excellent
Water of Plasticity	23.4%
Modulus of Rupture, pounds per square inch	468
Air Shrinkage, linear	7%
Color after firing	Red

If manganese is added to the material, a brown tile is produced. The firing temperature is 1750° F.

Stone

Each of the limestone-shale formations within the area contains beds of limestone suitable for road material and other purposes for which crushed stone is used. The supply of this resource is widely distributed, conveniently located, and inexhaustible. During the summer and autumn of

1930, the State Highway Department operated a quarry in the Golconda limestone beside Highway 60, near the head of Hites Run on the property of Scott Smart. In the summer of 1931 they were quarrying Glen Dean limestone one mile east of Cloverport on the land of Frank Carter.

The Murray Roofing-Tile Company has a large quarry for the production of crushed stone from the Glen Dean limestone near its clay products plant at Cloverport. The quarry and the clay pit are located where the Glen Dean formation is at its maximum thickness of one hundred feet. At this point the lower Glen Dean limestone is 45 feet thick and the upper limestone 11 feet thick with $6\frac{1}{2}$ feet of shale between, making a total thickness of 56 feet of limestone in the face of the quarry. This great thickness of good limestone so conveniently located on the railroad, river, and highway, together with the fact that the limestone is a sort of by-product of the production of clay, insures long continued and profitable operation of the quarry.

The region is also well supplied with building stones of the kinds suitable for rough construction such as bridge abutments, locks, dams, and foundations for farm buildings, and some of the sandstone and limestones might be used for finer construction. There are no quarries within the area producing building stones at present. This work has always been of a temporary nature, quarries being opened to supply a temporary demand and closed when the demand was supplied.

Of such a nature was the operation in the river bluff one mile above Stephensport on the property of J. W. French where a quarry was opened in Cypress, Golconda, and Hardinsburg for the construction of the Government Lock and Dam No. 45 at Addison. Basal Pottsville sandstone three-fourths of a mile north of Falls of Rough was used to build the mill dam at Falls of Rough.

At Hawesville, just west of the margin of Cannelton Quadrangle, the lower Pottsville sandstone was extensively quarried many years ago, furnishing what was said to be excellent building stone. From the quarries here, a large part of the rock for the locks on Green River, the government building at Memphis, and other extensive public works was obtained. A sample of the stone from this quarry received an award at the Centennial Exposition in Philadelphia in 1876.

Gravel

The Ohio River bed and the Pleistocene deposits beneath the river flats contain an abundance of good, hard, clean, well rounded gravels suitable for the best concrete work. The former may be procured by dredging and the latter by the open pit method.

Creek gravels are used locally, as at McQuady, in the construction or maintenance of county roads, but they are of inferior grade and not suited for highway construction nor for concrete. Chert gravels of Tertiary age occur at

several points near Ohio and Rough Rivers. The most extensive gravel deposits of this age are in Skillman Rectangle of Canneltown Quadrangle, at the 500 and 600 foot levels. There is a small area of good clean chert gravel of this age one and one-half miles northeast of Stephensonport at the 700 foot level. The gravels at the 600 and the 700 foot levels are cleaner, smoother, and contain a smaller percentage of sandstone pebbles, but those of the lower level are the only ones that have been used extensively.

A pit on the 600 foot gravels has been in operation intermittently for ten years or more on the farm of A. B. Sterrett on the Louisville and Nashville Railroad three-fourths of a mile southeast of Skillman. The last gravel taken from this pit was used in the construction of Highway 60. A description of the materials in this pit and a section of the deposit may be found in the discussion of the lithologic character of the Tertiary deposits on page 109. The area of Tertiary gravels at this point is small.

During the construction of Highway 60, the State Department of Highways also operated a gravel pit on the property of Martin Minnett at the 500 foot level one and one-half miles southeast of Hawesville. A description of this deposit is given on page 109. There is another pit just west of the one on Minnett's property on the land of T. D. Hale. The best immediate use of these gravels would be in the

construction of county roads.

Sand

Sands suitable for building and for use in brick making are found at various geologic horizons from the Bethel sandstone up to the Recent river deposits. Some portions of the Bethel, Cypress, Tar Springs, and Pottsville sands are good enough for making bottle glass and probably for higher grades of glass. It is probable that some of the loess deposits along Ohio River are suitable for molding sand.

Cement Materials

The raw materials for the manufacture of Portland Cement are present in great abundance in the two quadrangles. The shales of the different Chester formations together with the interbedded limestones crop out extensively in many localities. No analyses of these limestones are available but, if it should be known that they run low in magnesium, they probably would be suitable for the production of first class cement. The most favorable location for a cement plant would be either at Cloverport or Stephensport. Hawesville is too far from good outcrops of limestone and shale and the river towns have a decided advantage over those in the interior of the area.

Marl

Certain parts of many of the shale beds of the Chester

Series are sufficiently calcareous to be used locally as agricultural marl. The use of this readily available fertilizer, practiced to a very limited degree in the past, should be greatly increased.

Ground Water

The alternating series of sandstones, limestones, and shales creates the conditions necessary for the occurrence of numerous small springs which furnish the larger portion of the water supply in the rural districts. The same conditions favor the successful digging of shallow water wells of small production. It is never necessary to go very deep in order to strike a porous or jointed bed of sandstone or limestone underlain by relatively impervious shale. Very few big limestone springs occur in this area. The one at Tousey, however, has such a large volume that it formerly ran a grist mill.

Water sufficient to supply the needs of small towns may be found in the gravel beds of the unconsolidated Pleistocene and recent sediments along Ohio River. The town of Cloverport was having wells drilled during the summer of 1931 with the hope that two wells drilled to bed rock beneath the unconsolidated materials would supply the needs of the town.

In the days when the water from mineral springs was an unquestioned panacea, this region had its famous Tar

Springs three miles south of Cloverport to offer for the cure of the ills of humanity. Most of the product of this spring is what is usually called sulphur water, but a small quantity of petroleum issues with the water in tiny globules. This oil upon exposure darkens and hardens into a tarry mass, hence the name. There is much evidence of the occupation of this region by the Indians who probably learned to use the tar of Tar Springs much as we use salve.

The Breckinridge County Tar Springs were widely known and highly esteemed through the Mississippi valley before the Civil War but they were little used after about 1870 and few people ever go there now.

At one or two places along the Rough River Uplift the regular, evil tasting, vile smelling sulphur water wells up but it was never capitalized within this area as it was farther west at Sulphur Springs and farther east at Grayson Springs.

Water Power

Rough River is too small and too crooked ever to justify improvement for navigation purposes but it seems to offer possibilities for abundant water power. At Falls of Rough where the water formerly plunged over low ledges of lower Glen Dean limestone, water power has been utilized for many years in the operation of a flour mill and a saw mill. Hites Falls, where the river plunges over a low ledge

of Tar Springs sandstone four miles farther downstream, offers an opportunity for a similar installment. But these are small scale projects. A splendid location for a large scale water power project exists on the eastern side of "The Bend" near the eastern margin of Fordsville Quadrangle. The Government is interested in this project from the standpoint of flood control as well as that of water power. The other streams of this area are too small to be expected to generate much power.

Natural Scenery

Natural scenery is the direct product of the interoperation of geologic conditions and processes. The people of Switzerland and of other European countries long ago recognized that natural scenery which attracts visitors is a great economic asset. We of this country are just beginning to fully realize this fact and to capitalize our scenic beauties and to secure for ourselves the happiness which comes from the appreciation of our local natural scenery. We often dream of visiting distant places of interest, and yet are prone to overlook many exquisite gems of natural scenery at our own front doors. For example, the writer believes that America affords no more beautiful scenic drive than that between Cloverport and Hawesville. The variety of features of natural beauty along this short drive are remarkable. From the river front at Cloverport, as the sun

sets down the Ohio in the late summer afternoon, one may behold a scene that the old masters would have loved to paint. Along the road, ridge, knob, hill, chasm, cliff, forest, river, valley and lake all appear in kaleidoscopic fashion to delight the eye until the climax is reached at the top of the river bluff above Hawesville where the drive along the skyline combines the sense of great height with an unexcelled panorama of river, valley, forest, hill, and town.

Instead of pining over the recent loss of the railroad shops, it seems that Cloverport might more than recoup her fortunes by making the town and the surrounding region into a summer resort. Nature has provided in an excellent way for the water sports which everyone loves. The scenery of the region is remarkably beautiful and the State Highway provides a scenic drive. The town is easily reached by boat, rail, and highway. Living conditions are now healthful and could easily be made more so. Even Tar Springs water could be piped into town and an attempt made to revive its former fame. The best use of the region along the highway from Cloverport to Hawesville would be as a State Park. Why not make this locality a vacation center for the people of the Ohio valley?

A SELECTED BIBLIOGRAPHY

Butts, Charles

The Mississippian Series in Western Kentucky,
Kentucky Geological Survey, 1917.

The Mississippian Series in Eastern Kentucky, Ken-
tucky Geological Survey, Series VI, Vol. 7, 1922.

Chamberlain, T. C., and Salisbury, R. D.

On the Relationship of the Pleistocene to the pre-
Pleistocene Formations of the Mississippi Basin South
of the Limits of Glaciation. American Journal of
Science, 3rd Series, Vol. 41, pp. 359-377, 1891.

Chisholm, D. B.

A brief Report on the Geology of Hancock County,
Kentucky. Kentucky Geological Survey, Series VI,
Vol. 41, 1931.

Crider, A. F.

Economic Geology of Tell City and Owensboro Quad-
rangles, Kentucky Geological Survey, Series IV, Vol.
I, Pt. 1, Pages 263-277.

Fennemann, N. M.

Physiographic Provinces of the U. S. Annals of the
Association of American Geographers, Vol. VI, 1917.

Gardner, James H.

The Economic Geology of the Hartford Quadrangle, Ken-
tucky Geological Survey, Bulletin No. 20, Serial
No. 27, 1910.

Glenn, Leonidas Chalmers

Geology and Coals of Webster County, Kentucky
Geological Survey, Series VI, Vol. V, 1921.

Griffin, J. R., Culbertson, J. A. and Mayfield, S. M.

Areal Geologic Map of Breckinridge County, Kentucky
Geological Survey, Series VI, 1931.

Jillson, Willard Rouse

Geological Map of Kentucky, Kentucky Geological Survey, Series VI, 1928.

Oil and Gas Resources of Kentucky, Kentucky Geological Survey, Series V, Vol. I.

Peneplains in Kentucky, Kentucky Geological Survey, Series VI, Vol. 35, Pages 330-336, 1930.

Coal Industry in Kentucky, Kentucky Geological Survey, Series VI, Vol. 20, 1924, Pages 86, 93, 130.

Geology and Mineral Resources of Kentucky, Kentucky Geological Survey, Series VI, Vol. 17, 1929, Pages 35-36, 141-142.

Oil Field Stratigraphy of Kentucky, Kentucky Geological Survey, Series VI, Vol. 3, 1922. Pages 189-190.

New Oil Pools of Kentucky, Kentucky Geological Survey, Series VI, Vol. 12, 1926, Pages 1-32.

Oil and Gas in Western Kentucky, Kentucky Geological Survey, Series VI, Vol. 39, 1930. Pages 17-32, 469-471, 155-156.

Geological Survey Affairs, Kentucky Geological Survey, Series VI, Vol. 35.

Lesquereux, Leo.

Paleontological Report - Fossil Flora of the Coal Measures, Kentucky Geological Survey, Vol. 3, Pages 501-556, 1857.

Leverett, Frank

Pleistocene of Northern Kentucky, Kentucky Geological Survey, Series VI, Vol. 31, 1929, Pages 1-71.

Monograph XLI, U. S. Geological Survey, 1902.

Monograph LIII, U. S. Geological Survey, 1915.

Lyon, Sidney S.

Paleontological Report, 3rd Geological report, Kentucky Geological Survey, 1857, pages 531-534.

Mayfield, S. M. and Chisholm, D. B.

Map of the Areal and Structural Geology of Hancock County, Kentucky Geological Survey, 1931.

Miller, Arthur McQuiston

The Geology of Kentucky, Kentucky Geological Survey, Series V, Bulletin 2, 1919.

Moore, P. N.

On the Geology of Hancock County, Reports on Western Kentucky Coal Field, D. 1884, Pages 97-133.

On the Geology of the Region Adjacent to the Eastern Border of the Western Coal Field, from the Louisville Paducah, and Southwestern Railway to the Ohio River.

Kentucky Geological Survey, Report of Progress,
Vol. IV, New Series, Pages 389-421, 1878.

Norwood, Charles J.

A Report of a Reconnaissance of a part of the Breck-
inridge Cannel Coal District, Reports on Western
Coal Field, Kentucky Geological Survey, Pages 73-79,
1909.

A General Account of the Geology of a Part of Ohio
County, Part V, Volume V, Second Series.

Report on the Progress of the Survey for the years
1908 and 1909. Kentucky Geological Survey, Pages
73-79.

Orton, Edward

Occurrence of Petroleum, Natural Gas, and Asphalt
Rock in Western Kentucky, Kentucky Geological Sur-
vey, 1891, Pages 206-209.

Owen, David Dale

First report of the Kentucky Geological Survey, 1856.
Page 52, 62, 173-181.

Second Report of the Kentucky Geological Survey,
1857, Pages 53, 125, 138, 208-217.

Third Geological Report of the Kentucky Geological
Survey, 1857, Pages 225-227, 278-283, 457-463.

Fourth Report of the Geological Survey of Kentucky,
1858 and 1859, Page 97, Page 177, 504-505, 548-
551, 574.

Peter, Robert

Chemical Analyses, A. Kentucky Geological Survey,
1884, Pages 260-264, 374, 438.

Richardson, Charles Henry. Road Materials of Kentucky,
Kentucky Geological Survey, Series 6, Volume 22,
1924, pages 180, 22, 148, 139-150.

Ries, Heinrich.

The Clay Deposits of Kentucky, Kentucky Geological
Survey, Ser. VI, Vol. 8, 1922, p. 64-66.

Shaw, E. W.

Quaternary Lakes in the Mississippi Basin. Journal
of Geology, Vol. XIX, 1911, pp. 481-491.

Sutton, Arle H.

Geology of the Southern Part of the Dawson Springs
Quadrangle, Kentucky, 1927, Kentucky Geological
Survey, Ser. VI, Vol. 31, pp. 170-280.

Geology of Smithland and Eddyville Quadrangles,
1929, Kentucky Geological Survey, Ser. VI, Vol. 42.

Ulrich, E. O.

The formations of the Chester Series in Western
Kentucky and Their Correlates Elsewhere, Kentucky
Geological Survey, 1918.

Weller, Stuart.

Transactions of the Illinois Academy of Science,
Vol. VI, 1914.

Illinois State Geological Survey, Monograph I,

1914.

The Chester Series of Illinois, The Journal of
Geology, Vol. XXVIII, 1920.

Geology of the Golconda Quadrangle, Kentucky
Geological Survey, Ser. 6, Vol. 4, 1921.

Geology of the Princeton Quadrangle, Kentucky Geo-
logical Survey, Series 6, Vol. 10, 1923.

Geology of the Cave in Rock Quadrangle, Kentucky
Geological Survey, Series VI, Vol. 26, 1927.

Weller, J. Marvin.

Geology of Edmonson County, Kentucky Geological Sur-
vey, Ser. VI, Vol. 28, 1927.

